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ASTRONOMY and ASTRO-PHYSICS.

AUGUST, 1892.

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High School Algebra by W. J. Milne, Published by the American Book Company, New York, Cincinnati and Chicago.—Plane and Spherical Trigonometry by E. Miller, Professor of Mathematics and Astronomy in the University of Kansas. Published by Messrs. Leach, Shewell and Sanborn.—A Drill Book in Algebra by George William Jones, Ithaca, New York. Published by the author.—Determinaants by G. A. Miller of Eureka College. Publishers D. Van Nostrand Co., New York City.

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General Astronomy.

COLORS EXHIBITED BY THE PLANET MARS.*

WILLIAM H. PICKERING.

In my former paper upon this subject,† attention was called to the important effect of our own atmosphere in misleading our judgment as to the true colors exhibited by the heavenly bodies. A good illustration of this effect may be obtained from a mountain summit upon a slightly cloudy day. The distant greens of the landscape, which are by no means as brilliant as when viewed close at hand, are at once changed to grays either by the passing over them of a cloud shadow, or by the passing of a very thin mist between them and the eye. In the former case they become darker, and in the latter lighter, but in either case the greenish tint entirely disappears.

The sudden changes of color exhibited by some of the smaller areas upon the planet Mars are sometimes almost startling. A recent view was obtained shortly before sunrise, when the snowy region about the south pole appeared of a most brilliant green, quite equalling in color the rather narrow green band situated just to the north of it. Later as the Sun came up, the color of the snow changed to bright yellow, the rest of the disc changing in the mean time to orange. Later the seeing improved, several of the canals became visible, and the snow became as colorless as that upon our surrounding mountains. The two former effects were probably due to bad seeing, the fluctuations of our own atmosphere superposing the colors of the surrounding regions upon the snow. We have laid it down as a rule never to rely greatly upon our color observations unless the snow caps of the planet appear perfectly colorless, and the canal system is well defined. These conditions we find always combined with the best seeing. For these delicate color observations it will therefore be seen, that not only do we require a telescope of the very first quality, but also the very best obtainable atmospheric conditions.

* Communicated by the author. † See page 449, No. 6.

In studying the smaller dark regions, such as the northwestern part of the Syrtis major, great differences of color have been noted from night to night, and I have colored sketches in my possession, taken at different times, in which it is represented as grey, as green, as blue, as brown and even as violet. The latter color was so extraordinary that I endeavored to make that portion of the planet appear to my eye of some other color, but it was impossible, and no other color but violet lake could be made to match it. This color upon the planet has only been seen by me upon one occasion since. The brown color above noted was undoubtedly due to bad seeing. At one time I felt convinced that the real color of the darkest spots upon the planet was a deep blue, and this may in reality be the case, but of late, under the most favorable circumstances, they have appeared to me of an absolutely colorless dark grey. Probably this point can be settled at the present opposition.

Before describing the colors of particular regions more at length, it may be well to give a description of the general characteristics of different longitudes, as observed during the opposition of 1890. For this purpose we may divide the surface of the planet into six sections, each sixty degrees of longitude in breadth, the first leaving the 0° meridian central. The times of transit of the 0° meridian of the planet may be readily computed, but the amateur will find those given in convenient shape in the excellent ephemerides published by Mr. Marth in the *Monthly Notices*. The only pity is that these ephemerides cannot appear about six months earlier in order to be of the most use to astronomers outside of the British Islands.

The most striking marking upon the planet, and that most readily seen with a small telescope, is the Syrtis Major, or Y mark. This is nearly central in the sixth position of the planet, with the 300° meridian in the middle of the disc. Owing to the period of rotation of Mars being 37 minutes longer than that of the Earth, in about six nights Mars will be found at the same hour in the fifth position with the 240° meridian central. This region in 1890 was interesting as containing the most conspicuous canals visible upon the planet, excepting the large one which terminates the Syrtis Major upon the north. At this opposition these canals will all be too far north to be well seen. The fourth and third regions of the planet were both extremely uninteresting as showing very little detail of consequence. The second position with the 60° meridian central was interesting as showing the great southern ocean, which is nearly as conspicuous as the

Syrtis Major itself. In the first position with the 0° meridian central the ocean is disappearing and the Syrtis Major coming into view.

We now come to a curious feature of the observations, namely, the actual changes in color which, eliminating all probable sources of error, the surface of the planet really seems to undergo. When the Syrtis Major is central, before the autumnal equinox of the northern hemisphere, the region to the east is seen to be distinctly more greenish than that to the west. As the season wears on the difference in color becomes less marked, and the greenish hue is confined more closely to the region immediately bordering the Syrtis on the east. In most of my drawings made in 1890 the two arms of the Syrtis are shown of equal breadth. This appears to be the case also upon Green's map published in Chambers' Astronomy, although this point is not well shown by him. At present there is no doubt but that the eastern arm is much the wider of the two, perhaps twice as wide. Early in 1890 the entire region enclosed between the arms of the Syrtis Major, as far as the snow cap, was of a brilliant green color. On June 27 however, or eleven days before the vernal equinox of the southern hemisphere, a yellow spot appeared at the extreme northern point of the triangular area. As the season advanced this yellow spot increased in area, till it covered the whole region as far south as could be seen. This year when first observed, this area was entirely green, but on May 9, or seventeen days before the vernal equinox, the yellow or perhaps reddish spot appeared in the same place, and it will be interesting to determine if, as the season advances, this color again progress towards the pole. Changes to the east of the Syrtis Major have also been noticed by Schiaparelli. These he ascribes to extensive floods. On June 8, 1890, thirty days before the autumnal equinox in the northern hemisphere, there was a large greenish area visible in longitude 180°, latitude 30° north. By July 16, or eight days after the equinox, this spot could not be found, the whole region appearing of a yellow tint. In longitude 10°, latitude 40° north, is a large crescent-shaped area. In June and July, 1890, it was well seen and appeared quite as dark as the great southern ocean. This was noted upon a number of occasions. It was however painted green, and the ocean to the south of it blue, the difference in color on one evening being very clear, as seen by my assistant, Mr. A. E. Douglass, and myself. On March 22 of the present year the crescent was well shown, but was markedly fainter than the ocean, which was again suspected of being blue, but the color

could not be satisfactorily confirmed. This crescent is now too far north, owing to the motion of the planet, to be satisfactorily studied.

While these indications of change of color upon the planet are too few and isolated at present to enable us to form a satisfactory explanation of their causes, they still hold out a promise that should these observations be carefully repeated at future oppositions, under suitable conditions, we may in time be able to deduce the laws affecting them, and perhaps even predict their changes in advance. Too much stress however cannot be laid on the danger of optical illusion in this matter. It is generally considered that a very good instrument, and some practice is required, before an observer can certainly see the canals even, but in order that satisfactory results in this branch of the research may be achieved the more important canals must be seen with distinctness, and the snow caps, if present, must appear perfectly colorless.

AREQUIPA, Peru, May 13, 1892.

THE DOUBLE STAR, π^2 URSÆ MINORIS (Σ 1989.)*

S. W. BURNHAM.

But few measures have been made of this pair, although it is in a position to be observed at all observatories in the northern hemisphere on every night of the year. It is always moderately difficult with ordinary refractors, and the distance is still slowly decreasing. It is certainly a binary, but the period must be very long, as the angular motion in sixty years has been but about twenty degrees. With so small an arc it would of course be useless to attempt to obtain even an approximate period. It should be measured more frequently than heretofore to furnish the requisite data. It is probable that for some time to come the larger refractors will be necessary for this work.

The following are all the measures since the discovery of this pair by Struve:

	°	″		
1832.68	24.1	0.71	Σ	3n
1836.76	23.9	0.53	Σ	3n
1840.95	28.1	0.70	OΣ	3n
1841.46	23.0	0.85	Ma	1n
1858.59	21.1	0.60	Se	2n
1881.43	14.9	0.49	β	4n
1884.20	2.5	0.33	En	6n
1892.30	3.6	0.24	β	3n

* Communicated by the author.

The place of this star (1880) is:

R. A. $15^h\ 46^m\ 13^s$
Decl. $+80°\ 23'$

The magnitudes of the components are 7.1 and 8.1 in Struve. It seems to have been overlooked in the Harvard photometric Catalogue.

THE PROPER MOTION OF Σ 1603.*

S. W. BURNHAM.

This wide pair of bright stars has been known since 1783 when it was observed by Sir William Herschel. It was subsequently incorporated in Struve's great catalogue, and has been frequently measured by later observers. From these observations it appears that the components are relatively fixed. Stumpe in his catalogue of proper motions (*A. N.* 3000) assigns different proper motions to the components. This is probably based upon meridian observations, but it does not appear why data of this kind should be used when the micrometrical observations, so much superior to anything which could be derived from meridian circle work, are available for a comparison of the motion of the companion with that of the primary. Of course these measures give only the relative movement, and as no third star has been connected by observations with micrometer, the meridian position must be used to give the general drift of the system. The proper motion of A is given as 0″.189 in the direction of 259°.7, and of B, 0″.220 in 257°.9. This would imply a system similar to that of 61 Cygni. The direct measures, however, do not justify this conclusion.

The following is a complete list of all the measures down to the present time, including my recent observations at Mt. Hamilton:

	°	″		
1783.26		14.78	Herschel I	1n
1783.34	79.8	19.25	Herschel I	1n
1830.	81.5	20. ±	Herschel II	1n
1830.26	80.6	23.01	Herschel II	1n
1831.00	81.1	22.80	Herschel II	1n
1832.18	80.6	22.42	Struve	5n
1846.43	81.5	22.49	O. Struve	4n
1851.29	81.5	22.47	Dawes	1n
1858.28	81.5	22.26	Dembowski	1n
1863.25	78.7	22.94	Radcliffe	1n
1866.39	81.6	22.24	Dembowski	3n
1877.38	81.4	22.45	Hall	6n
1880.82	80.5	22.23	Bigourdan	1n
1883.20	82.0	22.33	Engelmann	5n
1892.37	81.7	22.30	Burnham	4n

* Communicated by the author.

The magnitudes according to Struve are 6.9 and 7.3, and it is, therefore, one of the easiest pairs in the sky to measure. It is evident that all of the measures prior to Struve, by the Herschels, and that at a later date made at the Radcliffe Observatory, are affected by large errors, and cannot be used at all in reference to relative motion. When the other measures are taken together it is absolutely certain that these stars have remained fixed with reference to each other from the first accurate positions by Struve in 1832 down to the present time, and that whatever the real proper motion may be, it is the same for each star. There is no need of further measures of this pair for many years.

NOTE ON THE HISTORY OF THE COLOR OF SIRIUS.*

T. J. J. SEE, BERLIN.

CONCLUDING NOTE.

Since my paper was finished in January last, I have had the benefit of the friendly criticism of several astronomers, and have ascertained the views of a number of others respecting the colors of the stars. Suffice it to say that as the result of this experience, I am the more fully convinced that if we are to believe the ancients in anything, we ought to believe them respecting the color of Sirius. For we must adhere to the evidence, unless there is reason to suspect its trustworthiness; and this being true, we could more logically conclude that Antares was white in antiquity than that Sirius was. All the different bits of evidence cited appear to be independent, for when any evidence of copying has been found, it has been pointed out; moreover, the research is a *comparative* one, since attention was given not only to what the authors say of Sirius but also what they say of other stars, and when the words seem to be loosely used attention is called to the uncertain value of the evidence. The summary on page 384 gives the authors in something like the order of their importance and probable trustworthiness; hence it will be observed that the poets are placed last on the list. Since the poets agree with the astronomers and philosophers it does not seem that they ought to be excluded; for if they had declared that Sirius was white, many would regard their testimony of great value and perhaps nearer the truth than that of "professional" observers. Therefore the present agreement ought to be

* Communicated by the author.

regarded as strongly confirmatory of the records left by Ptolemy, Geminus, Seneca, Pliny, Cicero, Aratus, Germanicus, Horace and Festus.

To those who ask whether the ancients did not observe the stars near the horizon, the answer is clear:—This was indeed true of some of the ancients, such as the (ancient) Egyptian priests, who wished to determine the place of the Sun among the stars; but *not true* of those who studied the constellations, charted the heavens, formed star-catalogues and traced the motions of the planets and Moon among the stars. Ptolemy and Geminus were professional astronomers, and Ptolemy has himself recorded in the Almagest that "we make our observations on the meridian of Alexandria." Among the ancient astronomers after the time of Timocharis (300 B. C.) the custom of observing on the meridian seems to have been in common use; we know positively that it was followed by Hipparchus; and Geminus, his contemporary and associate, must have followed the same method.

Moreover, we know perfectly well on general principles that the ancients, in studying the constellations (which they knew far better than the average even of intelligent moderns, because they lived more under the open sky and because their ideas of the gods naturally led them to be continually contemplating the stars) would, in the nature of things, come to know the appearance of the stars not when they were on the horizon but when high in the heavens. The ancients do not call Vega and Jupiter red, neither have I seen any case in which they are called fiery. Cleomedes says* Aldebaran and Antares are of the same size and color as Mars; moreover the very name Antares means "rival of Mars," and the body is spoken of by a number of writers as a "burning star" (ardenti astro).

Mars was given the name *πυροέις*, and connected with the god of war, because its color suggested blood. In the same way (in the opinion of the writer, at least), the Dog Star was named *Sirius* because its deep red color suggested "burning."† Venus was named from her beauty, and Jupiter (originally the god of the clear sky) from his clear, brilliant light ("salutary influence") and stately motion; Saturn from his pallid color and very slow motion among the stars, and Mercury because of his swiftness and appearance at dusk. Hyginus (reflecting, no doubt, the observation of some astrologer), says Saturn and

* Discovered since writing my paper on Sirius.

† Aratus says the star "most fiercely burns; and mortals call him Sirius."

Betelgeux, Jupiter and Vega, Mars, and fire are of the same color. Pliny assigns correct colors to all the planets, and distinguishes between the color of the Sun when rising and when high in the heavens; calls Sirius "burning" and says Canopus is "huge and bright." Seneca says Sirius was redder than Mars, and that Jupiter has no color at all. Cicero says the Dog Star "shines fervidly with a ruddy light;" and, speaking intelligently of the planets, declares that Mars is "ruddy and terrible to the earth." Germanicus says Sirius is "hurled in a ruddy course through the sky," and alludes to Antares as burning in the breast of the Scorpion; Manillius says the "Dog rages in its fire" and speaks of the "shining Scorpion with a burning star." Hesiod says Sirius "burns the face and knees," and Homer says it is an "evil omen, bringing much fever (something fiery) to wretched mortals." Euripides alludes to Sirius as sending "flames of fire" from the heavens, and Ap. Rhodius speaks of the star as "burning the Islands of Minos" (meaning some of the Cyclades). Aratus calls the Dog Star "colored" and Horace refers to the "red Dog," while Virgil speaks of both Sirius and Antares as "burning." At the Floralia Ovid tells us dogs were offered up on account of the Dog in the sky, and Festus says they were of a ruddy, nearly red, color, and sacrificed to placate the (angry) Dog Star in order that the blooming fruits might be brought to maturity. Columella compares roses to Tyrian purple, the rising Sun, ruddy Mars, and "Sirius fire;" while Eratosthenes says Venus and Vega are white, and that Mars is of the "nature of fire." Geminus says all stars have the same influence on the earth, and (indirectly) that the great multitude are "clear" while Sirius is "fiery." Lastly, Ptolemy says Aldebaran, Arcturus, Betelgeux, Pollux, Antares and Sirius are "fiery red." Do these facts indicate that the ancients were ignorant, careless, or color-blind, or that they observed the heavenly bodies on the horizon? There is evidently not the least logical ground for such a supposition, and those who adhere to the facts and follow the legitimate principles of historical research will reach the correct conclusion respecting the ancient color of Sirius.

ROYAL OBSERVATORY, Berlin, May 24th, 1892.

NOTE.—Some corrections and changes by the author will be found under Notes and News.—[ED.]

ON A PRETENDED EARLY DISCOVERY OF A SATELLITE OF MARS.

RALPH COPELAND, PH.D.

In the Crawford Library of the Edinburgh Royal Observatory is a quarto pamphlet of ten leaves, the complete title of which is: "Eberhard Christian Kindermanns, Königl. Pohl. und Churfürstl. Sächszl. Hof-*Math.* und *Astronomi*, Astronomishe Beschreibung und Nachricht von dem Cometen 1746. Und denen noch kommenden, welche in denen innen besagten Jahren erscheinen werden.—Dreszden, zu finden bey Gottlob Christian Hilschern, Hof-Buchhändler, 1746." Although Kindermann* thus held the post of astronomer to the King of Poland, who was at the same time Electoral-Prince of Saxony, the few observations he has placed on record have hitherto proved of very little value. Doubts, indeed, have at various times been expressed as to their general trustworthiness; nor is it quite certain that the comet of which the little book under consideration professes to treat ever really existed, although Kindermann gives the names of two persons and mentions a third by whom he alleges it to have been seen, as well as by himself. Dr. Hind, however, has succeeded in deriving a rough orbit from the fuller particulars given by Struyck, to whom Kindermann had communicated them. The tract also contains predictions of the return of three several comets, amongst them that of 1661, of which the elements, computed long previously by Halley, resemble those of the comet of 1532. Probably it was this resemblance which led Kindermann to assume their identity with a period of 129 years and a consequent return in 1790, a conjecture which, it is needless to say, was never realized.

These particulars are now of little moment, except in so far as they characterize the writer of the book, the frontispiece of which is sufficiently striking, containing, as it does, a little figure professing to show the orbit of a satellite of *Mars* discovered by the author. The encircling legend runs: "Via Luna (*sic*) Martis entdecket vom Autore den 10. Iul: 1744." On the face of the planet are various distinct markings, amongst which it is easy to recognize the long "dumb-bell," drawn by Divini and Cassini, and figured in the first volume of the *Philosophical Transactions*. The satellite is only removed about 2½ radii of *Mars* from the

* The Pulkowa Library contains three of his books, including the one described above.

centre of the planet. The satellite is nearly four-tenths of the diameter of the primary, and both bodies are liberally provided with atmospheres.

It may be mentioned that *Gulliver's Travels* were given to the world in 1726-7, while Voltaire's *Micromegas* seems to have been published about 1752. The statements they contain about the moons of *Mars* are widely known through Professor Hall's memoir. Kindermann's "discovery" is thus intermediate, in point of date, between the felicitous conceptions of the great satirists.—*Monthly Notices, May, 1892.*

PHOTOGRAPHIC SEARCH FOR A PLANET BEYOND THE ORBIT OF NEPTUNE.

ISAAC ROBERTS, F.R.S.

The hypothesis that one or more planets exist beyond the orbit of *Neptune* has been long entertained by astronomers, and Professor Forbes, in a remarkable paper on "Comets and ultra-Neptunian Planets," which he read before the Royal Society of Edinburgh at the beginning of the year 1880, predicted with considerable confidence that one or two such planets exist, and in the paper referred to he gave very fully his reasons.

The prediction was based upon the recorded positions of the aphelia of a number of comets. He said,* "That there could be no longer a doubt but that two planets revolve in orbits external to that of *Neptune*, one about 100 times, the other about 300 times the distance of the Earth from the Sun."

In 1887, November, I wrote to Professor Forbes to ask him if he had further considered the hypothesis concerning the supposed planets, and that I was prepared to make a search for them by photographic methods. In his reply he stated that the present position of one of the hypothetical planets is $11^h\ 48^m$ R. A. and 3° N. Declination, and he believed that a range of 5° each way in R. A. and of 2° or 3° in Declination ought to find the planet if it is there. The motion of the planet he computed at one degree in 2.96 years.

I thereupon commenced the search, but soon found that the climate of Maghull was so unfavorable for celestial photographic work of this character that my task was nearly hopeless; but since the removal of my Observatory to Crowborough I re-

* *Memoir*, p. 3.

sumed the search under conditions sufficiently favorable to complete the work, which was conducted on the following plan:—

A chart was made of the region indicated by Professor Forbes between R. A. $11^h\ 24^m$ and R. A. $12^h\ 12^m$ with Declination 0° 0′ to 6° 0′ North. This region was covered by eighteen photographic plates, each of more than four square degrees in area, and allowed of sufficient overlap to show a number of the same stars on two or more contiguous plates. Two sets of photo-plates of the region were taken with an interval of not less than seven days between the exposures, which were of ninety minutes duration, and the dual photographs were subsequently compared three times over by superposition, in order to see if any star appeared on one plate which was not on the other, or to see if change in the position of any star had taken place in the interval between the dual exposures. In this way the whole of the plates covering the region were very carefully examined, and it now only remains for me to report that no planet of greater brightness than a star of the 15th magnitude exists on the sky area herein indicated, nor is there on the plates any abnormal appearance to which it is necessary here to draw special attention. It is a region where the stars are not exceptionally numerous, and they are mostly faint. *Monthly Notices, May, 1892.*

CROWBOROUGH HILL, Sussex, 1892, April 12.

PHYSICAL OBSERVATIONS OF MARS.*

DR. TERBY, LOUVAIN, FRANCE.

On the 13th of May, from $8^h\ 7^m$ to $9^h\ 40^m$, I again saw the black thread; my drawings again show the displacement of the satellite polar spot by rotation; I satisfied myself that the companion spot was less brilliant and less white than the polar spot properly so-called; in other words the white light was at its maximum in the larger polar spot, and about which the satellite spot effected its movement of rotation. At $9^h\ 3^m$ the western extremity of the smaller spot was near the central meridian which corresponds to a longitude of 185°.6.

These observations then give us as approximate results: Martian longitude of the western extremity of the satellite polar spot, 185°.6. Martian longitude of the eastern extremity, 215°.3. Mean, or longitude of the middle, 200°.45. Martian

* Continued from No. 106, page 480.

longitude of the middle from direct observation, 204°.3 We must not forgot that these data are deduced from our drawings and not from observations made directly to this end. The agreement between the mean of the results obtained for the two extremities of the spot and the result obtained by the drawing for the middle of the supplementary snowy mass is nevertheless very remarkable; and we can attribute to the middle of the satellite spot, as a close approximation, the longitude of about 200°.

On the 18th, I again observed the little companion of the polar spot, always less white and less brilliant than the principal spot. On the 20th of May, it was even visible with the power of 180 diameters.

Whenever Elysium or the Trivium Charontis occupy the eastern half or right of the apparent disk, I have always perceived on the western or left limb, and on the prolongation of Erebus, some points or little white dots more or less brilliant, to the number of three under the most favorable conditions, occupying the vertices of a triangle; these points figure in twelve of my drawings.

These brilliant points have only been seen when they approach the west limb of the disk, and they become more and more visible, more and more white and shining, in proportion as they approach it more, until they end by passing beyond it by irradiation like the polar spot. We have not observed them in the vicinity of the central meridian, nor on the east limb, and I only know how to fix their position in a very approximate manner by the following process: on the 9th of May, from $9^h\ 10^m$ to $9^h\ 29^m$, these brilliant points were found on the extreme limb when the longitude of the central meridian was 225°.5; they could then have an approximate longitude of 135°. Further the prolongation of Erebus crosses this longitude in a Martian latitude of about + 40°. These snowy points are then found in a region near enough to that where M. Schiaperelli, in 1879, proved the existence of a snowy and brilliant prolongation of the polar spot and even an isolated snowy spot which he called Nix Olympica.

We find that in 1888 we have verified at Louvain the existence of the following canals, properly so-called; some canals remaining doubtful are marked with an interrogation point.

Artusapes, Phison, Typhonius, Orontes, Protonilus, Deuteronilus, Callirhœ, Euphrates (below Lake of Ismenius), Hiddekel and Gehon (traces), Indus, Oxus, Tanais, Jaxartes, Ganges, Nilokeras, Nilus, Ceraunius, Agathodæmon, Nectar, Gigas (?), Phlegethon (?), Acheron (?), Pyriphlegethon (?), Hades, Erebus, Cer-

berus, Styx, Eunostos, Hyblæus, Antæus, Cyclops (?), Triton, Lethes, Nepenthes, Thoth.

I observed Phison three times; the 29th of April, the first of June, and the second of June. The first time the canal appeared as a large rosy ribbon, very pale, perfectly straight; this observation, though difficult, did not leave the slightest doubt. The second and third time the ribbon appeared divided into two finer parts, perfectly straight and parallel; the difficulty of the observation gave rise to a slight doubt, but nevertheless such was the impression received.

As a proof of the impartiality with which these observations have been made, I will mention here that M. Schiaparelli, by a letter of the 28th of May, informed me of the existence of a very marked doubling in his 18-inch, that of the Euphrates, asking me to verify it. I expended every effort, after that date, to succeed in seeing the doubling of the Euphrates, but the canal itself has totally escaped me, with the exception of a piece of it which I saw under the Lake Ismenius on the 31st of May, and further, I have only identified this last in studying my drawings long afterwards and in beginning the preparation of this memoir.

The results deposited in this memoir are very small if one compares them to those which M. Perrotin has obtained at the Observatory of Nice, by the aid of the mammoth 30-inch telescope, the second instrument of the world, and to those which M. Schiaparelli has himself realized at Milan with his admirable 18-inch, especially in what concerns the doubling of the canals. I have said at the beginning that, in conditions so unfavorable, one could only hope for less still when using a simple 8-inch, however excellent it may be. But these results have an incontestible value in the presence of the incredulity with which certain astronomers still consider the beautiful discoveries of Milan. Who would believe it? In spite of the beautiful drawings of M. Perrotin, one reads still that the discoveries of M. Schiaparelli have not been confirmed by the largest instruments.*

We are then happy to bring our mite to the defense of the truth. Our excellent equatorial, comparable to that with which M. Schiaparelli made his first discoveries, has permitted us to verify the existence of a sufficiently great number of canals, and to get a glimpse of the doubling of one of them, in spite of the combination of deplorable circumstances which annihilated a great part of its power; above all it has caused us to even admire the general exactitude of the chart, to prove, for example, that not a

* English Mechanic, Jan. 1889, page 368.

single one of the white and brilliant spots which we have remarked on the limbs of the planet, as all observers have done for a long time, remained inexplicable to one who was provided with this almost infallible guide.

After what we have seen we dare to affirm that henceforth the progress of areography will be in the hands of those alone who, freeing themselves from the shackles of doubt, will resolutely engage in the way traced by the celebrated astronomer of Milan: A new era is begun in the study of Mars by the discovery of canals and of their doubling, and by the micrometric determination of 114 fundamental points of the map, an era succeeding to that which was inaugurated a half century ago by the construction of the first two hemispheres of Mars and by the approximate fixing of fourteen points by Mædler.—*Translated from the French by Roger Sprague, Berkley, Cal.*

THE NEW ENLARGING PHOTOGRAPHIC LENS.*

S. W. BURNHAM.

The proposed new lens by Dallmeyer for making an enlarged picture on the plate has attracted considerable attention. It has been given, somewhat in advance of any practical test of its usefulness, the rather complicated name of "telephotographic lens." Briefly stated it consists in the use of a double concave lens through which the light is passed, after transmission through the usual photographic objective, and distributed over a greater area of the plate, and thus giving an enlarged image, the scale of which will depend upon the relative focal lengths of the two lenses and the distance between them.

In the first place there is nothing new in the proposed device. A great many people who have gone into photographic experiments, the writer among the number have tried, with more or less success to get enlarged pictures of distant objects by photographing with an eye-piece placed between the principal lens and the plate. The most common instruments used in this way have probably been the ordinary lens with an eye-piece of some form, and the ordinary pocket telescope or spy-glass with its correcting eye-piece. The late Dr. H. D. Garrison and the writer tried a good many experiments with instruments of the last named form, but as the pictures were never quite sharp, the matter was aban-

* From *The Beacon*, April, 1892.

doned as not worth following up. We did not try, so far as I now remember, the double concave eye-piece. The proposed Dallmeyer lens is simply an objective fitted with a double concave eye-piece; in other words, an opera glass, and nothing else. Doubtless a skillful optician will be able to figure these lenses so that the resulting picture will be some sharper than that which would be made with a field or opera glass. How far any such combination will stand a severe test remains to be seen, but there is nothing new in the idea, and probably nothing new in the attempt to put it in practical shape.

In the second place, anyone who chooses to take a little trouble can at least roughly test the principle for himself at practically no expense at all. There is no reason why such a photographic lens, made in the usual way by manufacturing opticians, should cost much, if any, more than the ordinary rectilinear combination, and especially if a single achromatic can be used, as is probably the case, in place of the more expensive doublet.

I have tried a few experiments in the last day or two with my ordinary Laverne lens, which I have used in the camera for all purposes during the past five or six years. This has a focal length of about 8½ inches. I found among my possessions two double concave lenses, one which was formerly the eye-piece of a cheap opera glass, and the other a lens out of which I made some years ago a finder for my camera. This was before finders of this form were to be had in the market. A measurement of these lenses gave for the respective foci -1.6 and $+2.0$ inches. A trial of the first showed that it was inferior to the other, for the reason that its diameter was so small only a small part of the plate was covered, and therefore the other trials were made with the second lens. I send with this a print from a negative made with the Laverne lens in the regular way, and attached to it a print from an enlarged view of a small portion of the other picture. This was made placing the double concave lens at the proper distance behind the other lens for this enlargement. This gives a magnifying power of about seven diameters, and is therefore equivalent in size to a picture made with an ordinary lens of sixty inches focus. This was the maximum enlargement which could be made with the bellows extension of my camera. A greater enlargement probably could have been made without sensibly affecting the sharpness of the picture. The plate in this picture was about nineteen inches from the principal lens.

Of the success of the experiment it is unnecessary to speak, as the reproduced positive will show for itself. As a crude attempt,

with no accurate adjustment of the axes of the two lenses, to say nothing of the best relative foci, it is perhaps not unsatisfactory.

Anyone wishing to try his lens in this way can easily do it by getting at any optician's or dealer in lenses a double concave lens of one-half to one-fourth the focal length of that of the other lens to be used with it. This will only cost a dollar or two, and is all the outlay required. It will be better to set the photographic lens forward of its usual place in the front board by nearly its focal length, and use the cone or projecting tube as a support for the concave lens, which should be arranged to slide for a limited distance toward or from the front lens. As will be seen hereafter, a slight change in the position of the former will make a great difference in the scale or magnification of the image.

My friend, Dr. Henry Crew, of the Lick Observatory, who is an authority on all theoretical and practical questions relating to optics, has calculated the formulæ which govern the combination and use of lenses of this character. From these formulæ anyone with very little mathematical training can find for himself what lenses to use, and how they should be combined to produce a given result. This will be clear from the following:

A = focal length of the combination, that is, of a lens which would give a picture on the same scale as the enlarged picture.
F = focal length of the front double or single lens.
f = focal length of the concave lens.
d = distance between the two lenses.

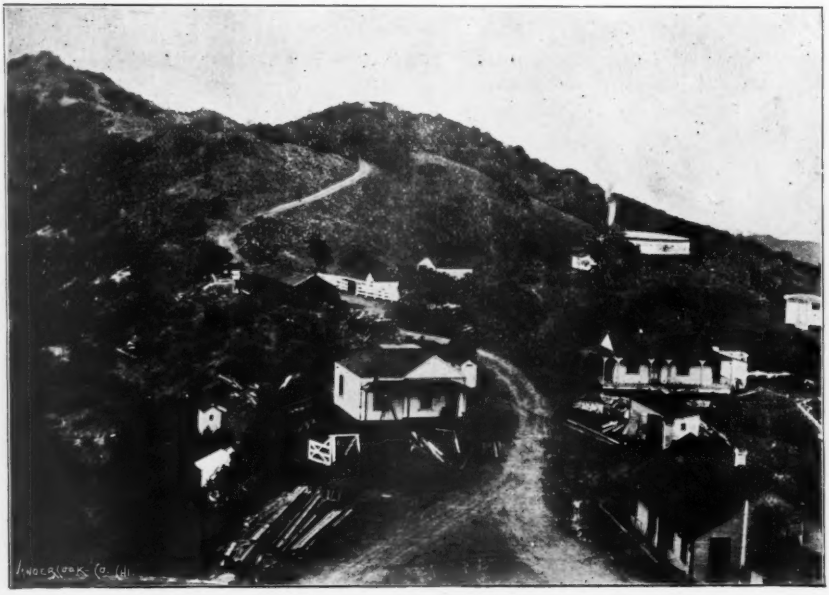
Then,

$$A = \frac{F \times f}{F + f - d}$$

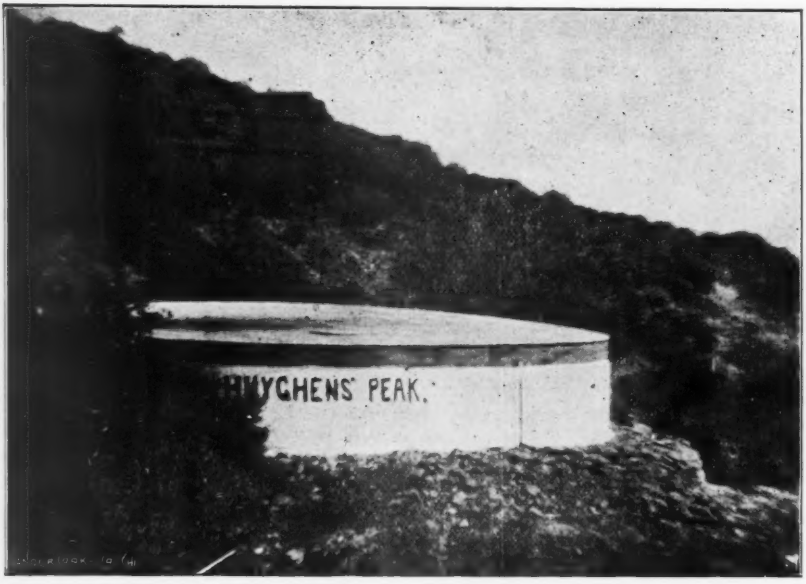
By substituting the known values of F and f, and assuming a value for d, we get at once the focal length of a single lens which would give a picture of the same size as that made by the new combination, and by dividing that quantity by the focal length of the front lens, we have the magnification given by the concave lens at this particular distance from the other. It must be remembered that the focal length of the concave, or negative, lens is a negative or minus quantity, and the resulting value of A must always be a positive or plus quantity. The practical use of the formula will be apparent from the following example, based upon the lenses which I have used in the experiments referred to, where F and f are respectively + 8.5 and — 2 inches. Let the assumed distance between the lenses be 7 inches and we have:

$$A = \frac{(+8.5) \times (-2)}{8.5 - 2 - 7} = \frac{-17}{-0.5} = +34$$

PLATE XX.



PHOTOGRAPHED WITH ORDINARY RECTILINEAR.



PHOTOGRAPHED WITH ADDED NEGATIVE LENS.

ILLUSTRATIONS OF MR. BURNHAM'S PAPER.

It is evident that the distance between the two lenses must always be greater than the difference between the two focal lengths, or, in this case more than 6½ inches; and that the maximum enlargement will be when the separation is nearest this limit, whatever may be the relative focal lengths of the two lenses. In the above example the photographic image would be magnified four times. If the assumed distance between the lenses had been 6.6 inches, the resulting value would have been 170 inches, giving a magnifying power of twenty. In the accompanying picture,* where the power is seven diameters, the lenses must have been separated about 6.8 inches. It will be seen that shifting the position of the concave lens by only one-tenth of an inch produces a large difference in the scale of the picture on the plate. It will also be observed that a highly magnified image can be obtained by reducing the difference between the focal length and the two lenses. For example, if I had used a concave lens of six inches focus, instead of two, and placed the lenses 2.6 apart, the picture on the ground glass would have been on the same scale theoretically, as if a single lens had been used of 500 inches focus. In practice, of course, the range of power would be limited, but I am unable to say how far it could be carried with any given lens before the image would become too indistinct and blurred. Doubtless the optician, by figuring these lenses with reference to their combination, will be able to produce a sharper magnified picture.

Another of the formulæ mentioned is important in this connection in order to determine the distance of the plate from the front whether the extension of the camera will be sufficient. If Y = the distance from the plate to the rear lens, then,

$$Y = A\left(\frac{F - d}{F}\right)$$

Substituting the values of these quantities as used in the experiment referred to, we have,

$$Y = 60\left(\frac{8.5 - 6.8}{8.5}\right) = 12 \text{ inches.}$$

Therefore the concave lens was 12 inches from the plate and, of course, the front lens 6.8 inches farther.

In making these enlarged pictures it is hardly necessary to say that the time of exposure is much increased. In the picture shown the exposure was about four or five seconds on a slow plate, with the front lens stopped down to $\frac{f}{22}$. Without

* Frontispiece in *The Beacon* for April, 1892.

the concave lens probably half a second was about the time for the other picture with the same aperture and light. By using a larger lens in front, if the necessary definition can be obtained in that way, the time can be considerably reduced.

The most useful and practical application of this principle would seem to be in fitting a properly corrected double concave lens to the rear of the ordinary rectilinear lens commonly used by all photographers. The former should be attached to a tube which could be screwed into the rear part of the mounting of the doublet. The concave lens should have a sliding motion in this tube to give the desirable range of magnifying power, which would be indicated by a graduated scale. As I have shown, this change in the position of the rear lens would be limited to a small distance. A system of lenses arranged in this way would possess the great advantage of allowing the doublet to be used in the usual way, and when the increased focal length was desired the rear lens could be screwed into place in a moment.

THE TOTAL SOLAR ECLIPSE, APRIL 15-16, 1893.*

The total eclipse of the Sun, which will take place during the month of April next year, will most probably be very widely observed, not only because the shadow of the moon passes over such a great stretch of land, but because the phenomenon occurs at the period when a sun-spot maximum is approaching, at which time, of course, the disturbed state of the atmosphere of the Sun is on the increase. The maximum time of totality is also in this case considerable, amounting to as much as $4^m\ 46^s$.

Path of Shadow.—The general trend of the path of the shadow will be gathered from the accompanying diagram (Fig. 1). This track cuts through Chili, passes to the north of the Argentine Republic, skirts the provinces of Bolivia and Paraguay, and runs through the heart of Brazil. The centre of the shadow leaves South America near the town of Ceara or Fortaleza, and travels across the Atlantic Ocean, striking the African coast between Cape Verde and Bathurst.

Probable Points for Observations.—The special points for observations may be said roughly to be three, viz.: the region about Chili, the northeast corner of Brazil, *i. e.*, the region of Ceara, and the Senegambian coast. These localities are so situated on the line of central and total eclipse that photographs of

* From *Nature*, June 30, 1892.

the corona taken at Chili will precede those taken in Africa by about 3½ hours; while those obtained in the northeast of Brazil will be intermediate between the two.

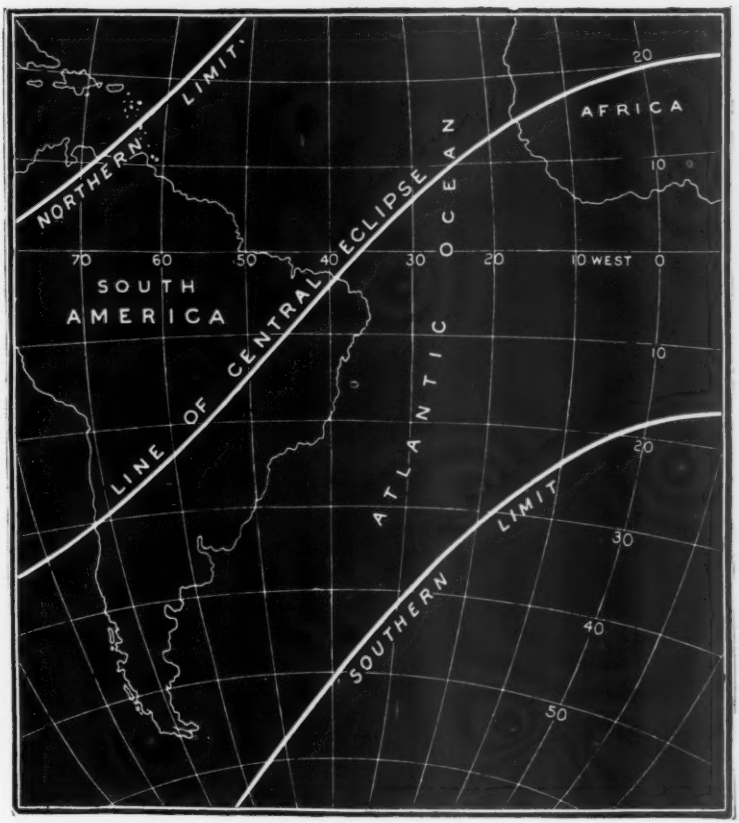


FIGURE 1.

Let us deal first with the Chilian district; this, we learn, will be occupied by the American astronomers. So far as we know at present, the Lick Observatory will send a party to Chili under the direction of Mr. Schaeberle, while Professor Pickering will also direct other observers somewhere about the same spot. To the north of the Argentine Republic, and on the Railway which runs up from Buenos Ayres, there seems to be another spot which

would be available. This place, Rosario de la Frontera, lies to the north of Tucaman, and to the south of Jujuy, its approximate position being longitude 65° 7′, latitude 25° 48′ S. The duration of totality here amounts to $3^m\ 8^s$, the local time of its commencement being April 15, $20^h\ 40^m$. This place should, if possible, be made use of, for, besides being easily accessible, the probabilities from all accounts seem to be in favor of fine weather. From observations gathered from the nearest meteorological station, Salta, the mean annual temperature is found to be 63°.6 F., and the rainfall 22.8 inches; the chances for clear weather at this season being estimated at two-thirds.*

Following the track of the shadow across Brazil, no suitable spots are reached until the coast is approached; the most favorable place here is no doubt Fortaleza or Ceara, the capital of the province of Ceara, and a city of 20,000 inhabitants. Para Curu is also another very favorable point, lying nearly in the centre of the line of central eclipse; its position is longitude 38° 30′, latitude 3° 42′ S., and the local time of the beginning of the eclipse is April 15, $23^h\ 40^m$, the time of its duration being $4^m\ 44^s$.

With regard to the weather in this neighborhood, the chances for clear skies seem unfortunately, very small. The rainfall is reckoned as over 100 inches per annum, while even in April 10 inches has been usually recorded. For the last five years fifteen days on an average in this month have been rainy, the number in one year reaching twenty-one.

Taking into account the easy accessibility of the place, and its important position on the line of totality, it seems desirable that at any rate there should be some observers there.

Following the shadow over the Atlantic Ocean, we arrive at the shores of West Africa, on which, probably both French and English expeditions will take up their respective positions. The accompanying map (Fig. 2) shows the coast-line of this region; AB, CD, and EF indicating the line of central eclipse and the northern and southern limits. The places which seem at present to be the most favorable are Joal and Palmerin, on the coast, if observations there are more convenient than others made inland.

The prospect of fine weather seems to be more probable here than in America. December, January, and February are the cloudy months, the weather during March and April being usually fine; the rains begin about May; sometimes tornadoes occur at intervals of five or six days, being accompanied by

* The information for the most part concerning the American stations is gathered from Mr. H. S. Pritchett's article, "The Total Solar Eclipse, April 15-16, 1893," in the June number of ASTRONOMY AND ASTRO-PHYSICS.

Fig. 2.—Showing the region on the West Coast of Africa over which the line of totality passes.

heavy rain, lasting generally from one to two hours, leaving the atmosphere afterwards bright and clear. The wind called the "Harmattan" during the first three months of the year is generally from the northeast and dry. It comes from the Sahara Desert, and brings with it consequently minute particles of sand, tending to give the atmosphere a yellowish tint. In April the prevailing wind is westerly to northwesterly, and not usually very strong.

The route which the English expedition will take has up to the present not been definitely settled. Several lines of steamers run to Teneriffe and Grand Canary, and if one of Her Majesty's ships picked the expedition up at Teneriffe and carried them either to Bathurst or directly to the Salum River, the matter would be simplified; but failing this the only available route seems to be that by the British and African Steam Navigation Company. These steamers, touching at Madeira, Teneriffe, Grand Canary, Goree, and Dakar, naturally require much time to get to Bathurst. Of the return conditions it seems impossible to get any information at present.

Taking into account the accessibility and proximity to the line of totality, perhaps Palmerin and other places on the same river (River Salum) offer the greatest advantages. The bar at the mouth of the river would prevent a man-of-war of deep draft from proceeding up the river. As the region here is all under French protection, the necessary official letters will of course have to be obtained.

There are one or two other points relating to this region if it should by any chance be ultimately settled upon. Luxuries in the way of tea, sugar, milk (condensed), cocoa and milk, condiments, wine or spirits, flour, biscuits, soups, and preserved meats, should all be brought from England; rice, fowls, sheep, goats, and bullocks being always procurable from the native villages.

Cement and lime should also be taken out, and it seems probable that the huts for the instruments should be constructed at home and carried out there in pieces. The necessary housing of the observers (and escort, if any) would not prove very difficult, for either room could be found in the villages, or bamboo and grass huts could be quickly run up by the natives; it might be advisable to take one or two small tents, as they might prove very serviceable just after landing.

With regard to the packing of the necessary instruments, it may be said that the carriers' loads vary from 40 to 65 pounds;

a case capable of being slung on a bamboo can weigh as much as 250 pounds, while to carry a weight of one hundredweight the services of two men would be required. Their wages would, of course, depend on whether they were obtained from Bathurst or the trading wharf on the river at the point of disembarkation, as in the latter case they could be discharged as soon as the selected spot had been reached.

NOTES ON NEW AND OLD NEBULÆ.*

LEWIS SWIFT.

In the February number of *Observatory* Mr. Denning published an article with the above caption to which I immediately replied, but for some unknown reason my answer has never appeared in that journal. Speaking of a bright nebula he had discovered about 2° S. E. of Gamma Camelopardis, of which the New General Catalogue contains no record, he says, "There is probably not another nebula so plain as this remaining to be discovered north of the equator." I began comet-seeking in 1857 with my present 4½-inch telescope, and constantly encountered nebulæ which, as I possessed no catalogue, I inferred were, of course, well known. From the start I marked their places by estimation on an old Burritt's Astronomical Atlas, for future reference, and from that date until my assumption of the directorship of the Warner Observatory in 1883, I had recorded some two hundred and fifty of these objects with no suspicion that a single one of them written down before 1879 was new. Consulting this map I find forty-eight recorded within 25° of the pole, one being nearly 2° S. E. of Gamma of the constellation named. I cannot recall its appearance or brightness or the year of its record, but to have been seen with so small a telescope it could not have been very faint. In comet sweeping for so many years I must have run across it many times. Some ten years since when comet seekers allotted to themselves a certain region for their quest, I notified them that I would mark their Burritt's maps with all the nebulæ I had discovered during more than twenty years, which I did, and on all the fifteen or more Atlases thus treated, including Professor Barnard's, the above nebula will be found. As a twenty-two foot equatorial is an inconvenient instrument for sweeping the polar regions, and as I supposed all of the forty-eight objects alluded to

* Communicated by the author.

were old, I have attempted to verify but few of them. These remarks have been suggested by a paper in *Astronomische Nachrichten*, No. 3097, by Professor Barnard on, "Two probably variable nebulæ," one of them being the identical one under discussion. After mentioning Mr. Denning's discovery on Nov, 7, 1890, he says, "I had previously discovered this nebula on August 23, 1889. It is 1′ in diameter, round, and in appearance is very much like a comet. . . . From its brightness it is not possible that it has been so conspicuous for any great length of time, or it would have been found by Swift and others. The fact that Mr. Denning and I independently found it within a little over a year is another proof that it must be brighter than in previous years." He gives the place of the nebula for Jan. 1, 1890, as Right Ascension $3^h\ 56^m\ 17^s$, Declination north 69° 30′ 38″.

I can conceive of no cause for the variability of nebulæ, and find no real evidence that any such exist, though, provided the purity of the atmosphere were the same on all occasions, the variability of his second suspect seems plausible. A slight change in this respect, which in a bright nebula would not be noticeable, could easily be detected in a very faint one. The same applies to bright and faint stars suspected or known to be variable.

I find some twenty or more nebulæ marked on my Burritt's chart in the vicinity of his second nebula, though none in the exact place of the object discovered by him on Nov. 30, 1888, in R. A. $0^h\ 37^m\ 55^s.71$; Decl. south 8° 48′ 6″.5.

WARNER OBSERVATORY, Rochester, N. Y., July 13, 1892.

THE NEBULAR HYPOTHESIS.*

When we look up at the clear sky at night, the stars and the planets seem to be equally distant, for the judgment of the eye is at fault for objects so remote; but astronomy teaches us that the Sun is a star, like the stars that we see in the sky, and that the planets, including the earth, revolve around him in obedience to the laws of gravitation, at distances which are insignificant in comparison with the vast intervals which separate the stars from one another. The Sun and planets, therefore, form a closely connected system isolated in space; they are members of one family, and their contiguity alone points to an identity of origin. We shall find many other facts bearing out the conclusion which we thus anticipate.

* A lecture by James E. Keeler, Allegheny Observatory, delivered before the Academy of Science and Art, of Pittsburg, on Nov. 6, 1891.

XUM

So far as we can know the manner in which the works of God are perfected, it is by a slow process of evolution rather than by special creation. The nebular hypothesis, which is our subject for this evening, seeks to explain the origin of the solar system, not by referring it to a special creative act of the Deity, but by regarding the Sun and planets as the result of development from a pre-existing form of matter, by the action of forces which are still in operation. The origin of matter is a mystery which the nebular hypothesis makes no attempt to solve.

It is evident that we are here outside the province of astronomy considered as an exact science, and are in the realms of hypothesis and speculation; but our speculations must be held tightly in check; they must be well within the bounds of probability, they must contradict no single natural law, and they must run in harmony with the whole course of the teachings of physical science; hence they can be profitably indulged in only by those profoundly versed in the laws of nature, and not by any one who chooses to give a loose rein to his imagination.

We have seen that the Sun is a star. Let us then look to the heavens above, to see if among the thousands of his compeers we can find something which will assist us in tracing the history of his past.

If, when you go out-doors this evening,* you will look up at the sky overhead, you will see in the constellation Andromeda at a point which I will presently describe more definitely, a very faint, almost imperceptible, patch of light. If you will look at this object with an opera glass, or better yet, with a large field glass, you will find that it is elongated, bright in the center, and fading gradually away at the edges until it is lost in the sky. This is the nebula of Andromeda, type of one of the two great classes into which the singular objects known as nebulæ may be divided.

Faint as this nebula appears to the naked eye, it is one of the brightest and largest in the heavens, so that it is sometimes called the "Queen of the Nebulæ." It is the only real nebula which was known before the invention of the telescope. Its real dimensions must be enormous. If we suppose the distance of the nebula to be no greater than that of the nearest star we see, its length must be more than 30,000 times the distance from the Earth to the Sun, so that the whole orbit of Neptune is insignificant compared with it. How much larger the nebula actually is than this, we have no means of telling. Professor G. P. Bond,

* Nov. 6, 1891.

one of the early directors of Harvard College Observatory, discovered two dark rifts or channels running along one side of the nebula, at places which are indicated in this diagram.

What is this nebula? It is the first and most natural question which it would occur to any one to ask; I must tell you at once that this question cannot yet be definitely answered, but I shall try to tell you some of the interesting facts that are known about the nebulæ. The last few years have added very much to our store of information.

It was once supposed that the nebulæ were aggregations of stars, so immensely distant that with the largest telescopes the individual stellar components could not be distinguished. In the constellation Hercules is an object which with a field-glass looks exactly like a nebula, but on employing a larger telescope it is resolved into a globular cluster of something like two thousand minute stars. It was thought that all nebulæ, if sufficient optical power could be brought to bear on them, would be similarly resolved into stars, but this was an error, for we now *know* that many of the nebulæ are not made up of stars at all.

No telescope revealed to the eye much more of the nature of the Andromeda nebula than what I have indicated in the diagram.* The principal reason for this is that the field of view of a large telescope is limited, so that the whole nebula cannot be seen at once. It was reserved for photography to reveal the true structure of this great nebula. We will project a view of it on the screen, and at the same time illustrate the disadvantage of a small field.

The first photograph which showed the structure of the Andromeda nebula was made by Mr. Roberts, of England. The one which we have in the lantern was taken by Mr. Barnard, of the Lick Observatory, with a comparatively small telescope, but it is of such exquisite sharpness that it shows everything on the larger photographs. Over the slide I have placed a piece of tin, in which there is a round hole. You therefore see upon the screen only a small part of the nebula, but the size of the hole is such that the small circle of light on the screen contains as much of the sky as can be seen at once with the great Lick Telescope. By moving the piece of tin about we can bring different parts of the nebula into view, but you see that in this way it is difficult to form an idea of the true shape of the object behind it. We now remove the tin, and the whole magnificent object is visible at a glance. Only one of the thousands of stars dotted over the screen is visible to the naked eye. Here are Bond's dark lanes, which you now recognize as elliptical, or rather spiral, rifts, extending completely around the nebula. At this place, near the center, a new star

* See Chambers' Astronomy, Vol. III, page 70. Also, Young's General Astronomy, page 504.

suddenly appeared in 1885, evidence of some tremendous cosmical convulsion which perhaps actually occured long before the discovery of America.

Andromeda Nebula from aPhotograph by Mr. Roberts, copied from *Himmel und Erde.* See, also, *Sidereal Messenger*, Vol. IX, Frontispiece. Cut does not show small field of the Great Lick Telescope.

You will notice that the whole aspect of the nebula suggests condensation toward the center, and that the arrangement of many stars in lines following the outlines of the nebula leaves little room for doubt that these stars and the nebula are in some way related.

[TO BE CONTINUED.]

ASTRO-PHYSICS.

ON NOVA AURIGÆ.*

WILLIAM HUGGINS, F.R.S., AND MRS. HUGGINS.

We had the honor in February last of communicating to the Royal Society a short preliminary note on the remarkable spectrum of this temporary star. We beg now to present a fuller account of our observations, together with two maps of the spectrum of this star, and some theoretical suggestions as to its nature. One map represents the result of our work by eye in the visible region; the other map has been drawn from a photograph of its spectrum, taken without its light having passed through glass, and which extends into the ultra-violet nearly as far as the absorption of our atmosphere permits even the solar rays to pass.

On the Visible Region of the Star's Spectrum.

The kindness of Professor Copeland in sending us a special telegram on February 1 enabled us to commence our observations of the star on February 2, when it was of about the 4.5th magnitude. These observations were continued on the following evening, and on the 5th, 6th, 22nd, and 24th February, and on the 15th, 18th, 19th, 20th, and 24th March, when the sky was more or less sufficiently clear for further observations to be made by eye. On the two ends of the spectrum the observations were usually made with a spectroscope containing one dense prism of 60°, but the comparisons in the brighter parts of the spectrum were observed with a more powerful spectroscope containing two compound prisms.

Comparisons with Hydrogen.—Three bright lines of great brilliancy, about the positions Hα, Hβ, and Hγ, left little doubt that they were due to hydrogen. The corresponding lines of a hydrogen vacuum tube were found to fall upon these lines, showing that they had their origin in this gas; but the line in the star at F, which could be best observed, showed a large shift of position towards the red. The line from the vacuum tube fell not upon the middle of the line, but near its more refrangible edge. The star line was brighter on the more refrangible side, so much so, indeed, that our first impression was that this side of the line only might be truly Hβ, and the less bright part towards

* Communicated by the authors.

the red, a line of some other substance falling near it. Subsequent observations of the hydrogen lines in the star left no doubt that though they presented the unusual character of being double, and sometimes triple, they were due wholly to hydrogen. These lines were rather broad, but defined, especially so on the more refrangible edge. Similarly to what is observed in the spectrum of terrestrial hydrogen, C was narrower than F, which again was less broad than Hγ near G.

The remarkable phenomenon presented itself that all the bright hydrogen lines and some other of the bright lines were doubled by a dark line of absorption of the same gas on the blue side. The shift of the dark hydrogen lines towards the blue showed a velocity of approach of this cooler gas somewhat greater than the recession of the gas emitting the bright lines. Our estimates of the relative velocity would place it at about 550 miles a second, which is in good accordance with the result obtained by Professor Vogel from the measurement of his photographs.

So far as our instruments enabled us to determine the point under the unfavorable condition of the rapidly waning light of the star, no material change in the relative motion of the gases producing the bright and dark lines took place from February 2 to about March 7, when the star's light became too faint for such observations—a result which we believe to be in accordance with successive photographs taken at Potsdam, Cambridge (U. S.), Stonyhurst, and some other observatories.

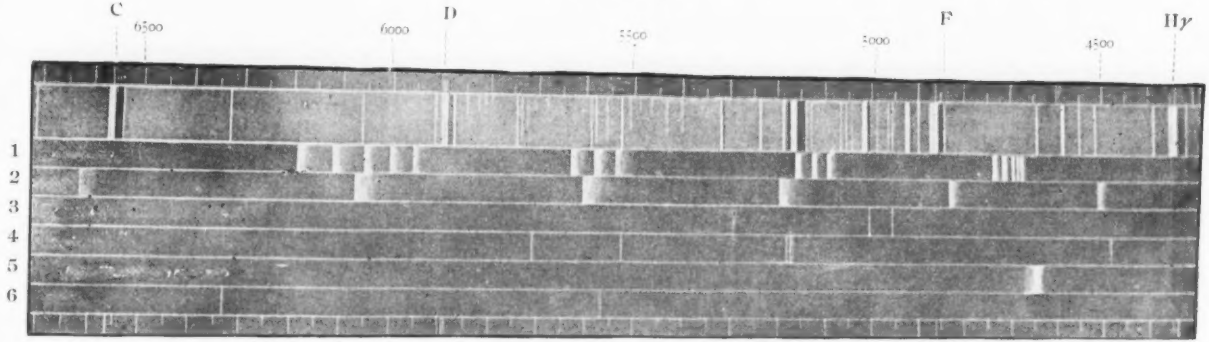
Comparison with Sodium.—A bright line, which on one occasion we glimpsed as double, appeared about the position of D.

Direct comparisons with a sodium flame, while leaving no doubt that the line was due to this substance, showed that it was shifted, similarly to the bright hydrogen lines, towards the red. Perhaps we should state that at the time we had the impression that this line was not shifted to so large an amount relatively to sodium as was the F line relatively to hydrogen. As the comparison was more difficult at this part of the spectrum, and one prism only was used, we do not attach importance to this observation.

Comparisons with Nitrogen and Lead.—There can be little doubt that one of the four brilliant lines in the green is the same line which appeared in the Nova of 1876, and was at that time suspected of being the chief nebular line. Very great pains were taken to ascertain its exact position and character.

For this purpose, on February 2, and again on February 3, direct comparisons were made with the more powerful spectro-

PLATE XXI.



"1. *Hydrocarbon.* 2. *C. Oxide.* 3. *Nebula.* 4. *Mg.* 5. *Wolf-Rayet Stars.* 6. *Aurora.*"

scope of the star's line with the brightest double line of the nitrogen spectrum, and also with a line of lead, to which line the near relative position of the nebular line is accurately known. Comparisons on both nights, and with both lines, showed that the star line was certainly less refrangible than the chief nebular line, and by a much larger amount than the shift of F relatively to hydrogen. A similar conclusion has been arrived at by Professor Young, Professor Vogel, Professor Campbell, at the Lick Observatory, Father Sidgreaves, Dr. Becker, and M. Bélopólsky, at Pulkova. The position of the line in the star is about λ 5014 and the line may well be one about this position which is frequently seen bright at the Sun's limb.

It may be added that though three faint bright lines are to be seen in the star's spectrum, not far from the place of the second nebular line, no one of them can be regarded as that line. Indeed no certain evidence exists that the chief nebular line occurs without the second line. In some cases of my early observations on the nebulæ in which I recorded the spectrum as consisting of one line only, I have since with better instruments been able to see the second and third lines as well. The origin of the second, as well as that of the chief nebular line, is not known. Professor Keeler has shown that the second nebular line is not coincident with the double line of iron, which is very near it.

The conclusion that the spectrum of the Nova has no relationship with that of the bright-line nebulæ would be strengthened, if further confirmation were needed, by the absence in a photograph we took of the spectrum of the New Star of a very strong ultra-violet line which is usually found in the spectrum of the nebula of Orion.

Comparison with the Hydrocarbon Flame and Carbon Oxide.—The brightest line in the spectrum of the Nova, with the exception of F, falls near the brightest edge of the green fluting of the hydrocarbon flame. Direct comparisons showed the star line to fall a little to the red side of the edge of the fluting; but, allowing for a shift of the star's spectrum, the place of the line would be near, though not coincident with, the brightest edge of the fluting.

The character of the star line leaves, however, no doubt on this point, for it is multiple with the brightest and most defined line on the blue side, contrary to the fluting which is defined on the red side, and gradually falls off towards the blue. If any uncertainty could be supposed still to remain, it was wholly removed when we found no brightenings in the star's spectrum corres-

ponding to the other flutings of the hydrocarbon flame. A bright band in the blue falls just beyond the fluting in this region. This band may have the same origin as a similar band in certain of the Wolf-Rayet stars.

We conclude that the spectrum of the Nova has no relationship with the usual spectrum of comets.

We found from direct comparison that the different set of flutings characteristic of the carbon oxide spectrum was not represented by any corresponding brightenings of the spectrum of the Nova.

Comparison with Magnesium.—It was not unreasonable to suppose that the star line might have its origin in magnesium, the triple line of which at *b* falls almost at the same place. The comparison showed the stellar line falling upon the more refrangible pair of the magnesium triplet, and to overlap it slightly on both sides, but rather more on the blue side. Considering that with the resolving power used the three lines of the triplet were well separated, and that we sought in vain for a similar triplet in the star; and, further, that if the probable shift of the star's spectrum towards the red be taken into account, the star line would fall rather more to the blue side of the more refrangible pair of the triplet, we consider it probable that the star line has some other origin. The stellar line is multiple, but it was found difficult to observe it with a sufficiently narrow slit. A thin and defined bright line was clearly seen at the blue side of the rather broad stellar line, but the remaining and less bright part of the line was not certainly made out, but on one occasion it was more than suspected of consisting of several lines.

We consider the evidence to be against the star line having its origin in magnesium, especially as no correspondingly bright lines were observed in the Nova at the positions of the other strong lines of the spark spectrum of magnesium, nor in our photograph at the position of the strong magnesium triplet a little more refrangible than H.

The third bright line in the green of the Nova which is nearest to F, and the least brilliant of the lines in this region, was found to have a wave-length of about λ 4921. A large number of bright lines were seen in the spectrum besides those which have been entered on the map.

The lines only of which we were able to fix the position with approximate accuracy are drawn across the spectrum. The places of the lines drawn partly across the map are from estimations only.

We observed a line a little more refrangible than D, of which the position when corrected for the shift of the spectrum, is at or very near that of D_3. Also a bright line below C, and others between C and D.

On February 2 and February 3 groups of numerous bright lines crowded the spectrum between *b* and D, which were less easily seen as the star waned.

The continuous spectrum extended, when the star was brightest, below C, and as far into the blue as the eye could follow it, at this time to a little distance beyond G.

The visible spectrum of the Nova, and especially the reversal of H and K, and of the complete series of the hydrogen lines in the ultra-violet, together with the probable presence of D_3, suggests strongly a state of things not unlike what we have in the hotter erupted matter at the solar surface. In a photograph of a prominence taken on March 4, 1892, which I have received from M. Deslandres, not only H and K and the complete series of hydrogen lines are reversed, but three bright lines appear beyond which may be more refrangible members of the same series.*

Photograph of the Ultra-Violet part of the Spectrum.—On February 22 and March 9 we took photographs of the star with mirror of speculum metal and a spectroscope of which the optical part is made of Iceland spar and quartz.

The photographs taken on February 22 with an exposure of 1¾ hour surprised us in showing an extension of the star spectrum into the ultra-violet, almost as far as the limit imposed upon the light of celestial bodies by the absorption of our atmosphere.

Not only the hydrogen lines near G and at *h*, but also H and K, together with the complete series which appear dark in the white stars, came out bright, each with its corresponding absorption line on the blue side. There are some inequalities of brightness in these lines, especially in the line δ, which is brighter than γ or β, which probably arises from lines of other substances falling near them. On this night K was followed by a strong absorption, which was less intense than the absorption at H.

Beyond the hydrogen series the spectrum is rich in bright lines, which, in most cases, are accompanied by lines of absorption. Necessarily, from the long range of spectrum included on the plate, the scale is small, and for this reason, and from the faint-

* M. Deslandres informs me that his measures of the position of the three lines falls into Balmer's formula for the hydrogen series. We must regard them, therefore, as members of that series, and due to hydrogen. June 1.

ness of the more refrangible portion of the spectrum when observed under the measuring microscope, the positions given to the stronger groups, which alone have been inserted in the map, must be regarded as approximate only.

Below the spectrum of the Nova, the spectrum of Sirius has been drawn for comparison. The group near the more refrangible limit of the spectrum* has been drawn in. Numerous other lines between this group and the end of the hydrogen series have been detected in our photographs of Sirius, but have not yet been measured with sufficient accuracy to justify us in putting them into the map.

In this map the shift of the spectrum of the Nova has not been attempted to be shown. The bright lines in the star have been put at the places of the hydrogen lines.

To the extreme limit of the spectrum a faint continuous spectrum shows itself.

The photograph of March 9, exposed for 1½ hour, was rather faint, as the state of the sky was unfavorable.

The apparently Multiple Character of the Lines.—On February 2 we noticed that the F line was not uniform throughout its breadth, and soon came to the conclusion that it was divided, not quite symmetrically, by a very narrow dark line. The more refrangible component was brighter, and rather broader than the other. Later on in February we were sure that small alterations were taking place in this line, and that the component on the blue side no longer maintained its superiority. We suspected, indeed, at times that the line was triple, and on towards the end of February and in the beginning of March we had no longer any doubt that it was occasionally divided into three bright lines by the incoming of two very narrow dark lines.

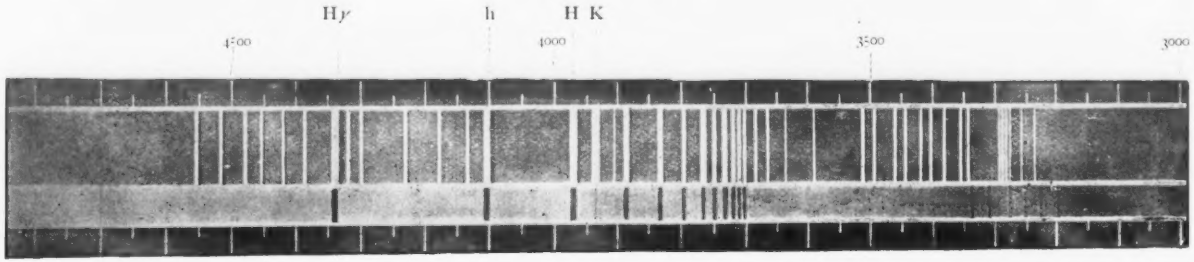
Similar alterations, giving a more or less apparent multiple character to the lines, are to be seen not only in the bright lines, but also in those of absorption in contemporary photographs taken of the spectrum of the star. I may mention those taken at Potsdam, Stonyhurst, and the Lick Observatory. They were specially watched and measured by M. Bélopólsky at Pulkova.

Professor Pickering informs me that on a photograph taken at Cambridge, U. S., on February 27, H, K, and α are triple, and that Miss Maury recorded, "the dark hydrogen lines rendered double, and sometimes triple, by the appearance of fine bright threads superposed upon the dark bands."

To explain these appearances on the assumption that each com-

* *Roy. Soc. Proc.*, vol. 48, p. 216.

PLATE XXII.



ponent of the bright and dark lines is produced by the emission or absorption of hydrogen moving with different velocities would require a complex system of six bodies all moving differently.

A much more reasonable explanation presents itself in the phenomena of reversal, which are very common on the erupted solar surface and in the laboratory.*

Professor Liveing informs me that he and Professor Dewar, in their researches with the arc-crucible, met with cases in which, through the unequal expansion of the bright line on the two sides, the narrow reversed dark line did not fall upon the middle of the broader bright line, but divided it unsymmetrically. This effect was notably shown in photographs which they took of the spectrum of zinc. Unsymmetrical division of the lines by reversal would also come in, if the cooler and hotter portions of the gas were possessed of relative motion in the line of sight.

These observers met also with double reversals which gave a triple character to the expanded single line. In one experiment, when sodium carbonate was introduced into the arc, the reversed D lines were seen as a broad dark band with a bright diffuse band in the middle. As the sodium evaporated the band narrowed, and the bright line in the middle showed a second reversal within it. This was a case of threefold reversal.

There would seem to be little doubt but that the more or less divided character—sometimes unsymmetrically—of the bright and dark lines of the Nova, which appeared to be undergoing continual alterations, was due to the incoming upon the broader lines of narrow reversed lines, bright or dark, as the case might be. Provision must therefore be made for conditions favorable for such reversals in any hypothesis which is suggested to account for the phenomena of the new star.

Waning of the Star.—The first record of this star was its appearance as a star of the 5th magnitude on a plate taken at Cambridge, U. S., on December 10, 1891. No star so bright as the 9th magnitude was found at its place on a plate taken by

* M. Deslandres permits me to quote the results of his recent observations on this point. "Lorsque l'on dirige sur la fente d'un spectroscope de grande dispersion l'image d'une facule du Soleil on a invariablement avec les raies H et K du calcium un renversement triple. Même, lorsque les facules sont larges et intenses, on obtient encore un renversement triple avec les raies brillantes centrales, plus faibles il est vrai, si l'on envoie dans le spectroscope la lumière de tous les points du Soleil, comme c'est le cas pour les étoiles; par example en dirigeant le collimateur vers le Soleil sans l'intermèdiaire d'aucun objectif, ou encore en le dirigeant vers un point quelquonque du ciel. Si elles sont au centre la raie centrale est à sa place normale, si elles sont à l'est ou à l'ouest la raie centrale est deplacée légèrement (2 kil. au plus) mais deplacée surement. Au point de vue pratique cette propriété fournit un moyen de reconnâitre l'état général de la surface solaire lorsque le Soleil est caché par les nuages."

Dr. Max Wolf on December 8. Combining the photographic magnitudes obtained at Greenwich with the visual ones made at the University Observatory, Oxford, and by Mr. Stone and Mr. Knott, we find that throughout February and the first few days of March the light of the star declined very slowly, but with continual and considerable fluctuations, from about the 4.5th magnitude down to the 6th magnitude. After March 7, the remarkable swayings to and fro of the intensity of its light, set up probably by commotions attendant on the causes of its outburst, calmed down, and the star fell rapidly and with regularity to about the 11th magnitude by March 24, and then down to nearly the 14.4th magnitude by April 1. On April 26, however, it was still visible at Harvard Observatory as a star of the 14.5 magnitude on the scale of the meridian photometer.

We observed its spectrum for the last time on March 24, when it had fallen to nearly the 11th magnitude. We were still able to glimpse the chief features of its spectrum. The four bright lines in the green were distinctly seen, and appeared to retain their relative brightness; F the brightest, then the line near *b*, followed by the lines about λ 5015 and 4921.

Traces of the continuous spectrum were still to be seen. Considering the much greater faintness of the continuous spectrum when the star was bright on February 2 than the brilliant lines falling upon it, we are not prepared to say that the falling off of the continuous spectrum was greater than might well be due to the waning of the star's light.

Professor Pickering informs me that in his plates "the principal bright lines faded in the order K, H, *α*, F, *h*, and G, the latter line becoming much the brightest when the star was faint." The calcium lines, K and H, showed signs of variation during the whole time of the star's visibility, and I may remark that the order of the other lines agrees with the relative sensitiveness of the gelatine plate for these parts of the spectrum. Professor Pickering's photographic results appear to us to agree with those we arrived at by eye, in not showing any material alteration in the nature of the star's light, notwithstanding a very large fall of intensity.

General Conclusions.

Among the principal conditions which must be met by any theory put forward to account for the remarkable phenomena of the new star stands the persistence without any material alteration —though probably with small changes—of the great relative ve-

locity of about 550 miles a second in the line of sight between the hydrogen which emitted the bright lines and the cooler hydrogen producing the dark lines of absorption.

If we assume two gaseous bodies, or bodies with gaseous atmospheres, moving away from each other after a near approach, in parabolic or hyperbolic orbits, with our Sun nearly in the axis of the orbits, the components of the motions of the two bodies in the line of sight, after they had swung round, might well be as rapid as those observed in the new star, and might continue for as long a time without any great change of relative velocity. Unfortunately information as to the motions of the bodies at the critical time is wanting, for the event through which the star became suddenly bright had been over for some forty days before any observations were made with the spectroscope.

Analogy from the variable stars of long period would suggest the view that the near approach of the two bodies may have been of the nature of a periodical disturbance, arising at long intervals in a complex system of bodies. Chandler has recently shown in the case of Algol that the minor irregularities in the variation of its light are probably caused by the presence of one or more bodies in the system, besides the bright star and the dusky one which partially eclipses it. To a similar cause are probably due the minor irregularities which form so prominent a feature in the waxing and waning of the variable stars as a class. We know that the stellar orbits are usually very eccentric. In the case of γ Virginis the eccentricity is as great as 0.9, and Auwers has recently found the very considerable eccentricity of 0.63 for Sirius.

The great relative velocity of the component stars of the Nova, however, seems to suggest rather the casual near approach of bodies possessing previously considerable motion; unless we are willing to concede to them a mass very great as compared with that of the Sun. Such a near approach of two bodies of great size is very greatly less improbable than would be their actual collision. The phenomena of the new star scarcely permit us to suppose even a partial collision; though if the bodies were very diffuse, or the approach close enough, there may have been possibly some mutual interpenetration and mingling of the rarer gases near their boundaries.

A more reasonable explanation of the phenomena, however, may be found in a view put forward many years ago by Klinkerfues, and recently developed by Wilsing, that under such circumstances of near approach enormous disturbances of a tidal nature

would be set up, amounting it may well be to partial deformation in the case of gaseous bodies, and producing sufficiently great changes of pressure in the interior of the bodies to give rise to enormous eruptions of the hotter matter from within, immensely greater, but similar in kind, to solar eruptions.

In such a state of things we should have conditions so favorable for the production of reversals undergoing continual change, similar to those exhibited by the bright and dark lines of the Nova, that we could not suppose them to be absent; while the integration of the light from all parts of the disturbed surfaces of the bodies would give breadth to the lines, and might account for the varying inequalities of brightness at the two sides of the lines.

The sources of the light of the continuous spectrum upon which were seen the dark lines of absorption shifted towards the blue, must have remained behind the cooler absorbing gas; indeed must have formed with it the body which was approaching us, unless we assume that both bodies were moving exactly in the line of sight, or that the absorbing gases were of enormous extent.

The circumstance that the receding body emitted bright lines, while the one approaching us gave a continuous spectrum with broad absorption lines similar to a white star, may, perhaps, be accounted for by the two bodies being in different evolutionary stages, and consequently differing in diffuseness and in temperature. Indeed in the variable star β Lyræ, we have probably such a binary system, of which one component gives bright lines, and the other dark lines of absorption. We must, however, assume a similar chemical nature for both bodies, and that they existed under conditions sufficiently similar for equivalent dark and bright lines to appear in their respective spectra.

We have no knowledge of the distance of the Nova, but the assumption is not an improbable one that its distance was of the same order of greatness as that of the Nova of 1876, for which Sir Robert Ball failed to detect any parallax. In this case, the light-emission suddenly set up, certainly within two days and possibly within a few hours, was probably much greater than that of our Sun; yet within some fifty days after it had been discovered, at the end of January, its light fell to about $\frac{1}{300}$ part, and in some three months to nearly the $\frac{1}{10000}$ part. As long as its spectrum could be observed the chief lines remained without material alteration of relative brightness. Under what conditions could we suppose the Sun to cool down sufficiently for its light to decrease to a similar

extent in so short a time, and without the incoming of material changes in its spectrum. It is scarcely conceivable that we can have to do with the conversion of gravitational energy into light and heat. On the theory we have ventured to suggest, the rapid calming down, after some swaying to and fro of the tidal disturbances and the closing in again of the outer and cooler gases, together with the want of transparency which might come in under such circumstances, as the bodies separated, might account reasonably for the very rapid and at first curiously fluctuating waning of the Nova; and also for the observed absence of change in its spectrum.

I may, perhaps, be permitted to remark that the view suggested by Dr. William Allen Miller and myself, in the case of the Nova of 1866,* was essentially similar, in so far as we ascribed it to erupted gases .The great suddenness of the outburst of that star, within a few hours probably, and the rapid waning from the 3.6 magnitude to the 8.1 magnitude in nine days, induced us to throw out the additional suggestion that possibly chemical actions between the erupted gases and the outer atmosphere of the star may have contributed to its sudden and transient splendor; a view which, though not impossible, I should not now, with our present knowledge of the light-changes of stars, be disposed to suggest.

PRINGSHEIM† ON KIRCHHOFF'S LAW.‡

HENRY CREW.

It will be remembered that in the demonstration which Kirchhoff gave (*Pogg. Ann., Bd. 109, pp. 275-301, 1860*) for his law connecting the absorption and emission of radiant energy, he made the whole of his mathematical deduction rest upon the experimental basis that a body, placed within an enclosure whose walls are held at a constant temperature, will assume and maintain the temperature of the walls, whatever be their nature or the disposition of their parts. But, as Kirchhoff then pointed out, this demonstration does not hold when the radiation absorbed by any body is transformed into any kind of energy other than heat; nor is it valid for radiation produced by any means other than simple heating.

* Roy. Soc. Proc., vol. 15, p. 146.
† Pringsheim, *Wied. Ann. Bd. 45, pp.* 428-459. (1892.)
‡ Communicated by the author.

If, for instance, the incident radiation were changed into any other form of energy than heat, it would not be registered on the thermometer. Likewise, if the radiation emitted by the body were at the expense, say of chemical energy, a decrease of temperature corresponding to the energy radiated would not be registered on the thermometer.

A glance at the text books, *e. g.* Wüllner's *Experimental Physik*, suffices to show that Kirchhoff's law has generally been illustrated by the solar spectrum and the spectra of the fixed stars, as well as by luminous flames. All assumptions, however, regarding the constitution of the stars are based upon evidence obtained from flames in the laboratory. In view of these facts, the paper which Mr. Pringsheim prints in the current number of *Wiedemann's Annalen* becomes one of more than ordinary interest, not that it will in any degree affect present views regarding the physical constitution of the stars, but rather because it throws new light on the manner in which stellar constituents are made known to us. It must not be forgotten that the solitary basis of *interpretation* of stellar spectra is laboratory work. Stars can be observed, but experiments* cannot be tried upon them.

After pointing out that our knowledge of highly heated gases is very meager, and that there is no *evidence* for thinking that gases become luminous when merely heated, Mr. Pringsheim proposes for solution these two questions.

(1.) Do gases possess the property of becoming luminous by a simple increase of temperature?

(2). Is there any gaseous source of light known which fulfills the conditions of Kirchhoff's Law?

The first of these problems was attacked by heating sodium vapor in a long porcelain tube which was placed in a specially designed gas furnace capable of producing temperatures considerably above one thousand degrees. At first the substances to be examined were introduced into the tube while c ld. On the ends of this porcelain tube were then cemented plane parallel glasses and portions of the tube near the end were cooled by running water: so that the cemented ends served to make the tube airtight. A small side tube, containing a four-way stop-cock, branched off from the porcelain tube. By this means, the tube could be emptied of air and filled with a neutral gas, such as nitrogen or carbon dioxide. This, of course, was for the prevention of chemical action during the heating. For observing the absorp-

* See Maxwell's *Scientific Papers, Vol. II., p. 505.*

tion spectra an argand burner was placed before the far end of the porcelain tube. The continuous spectrum of this flame could be viewed, through the heated vapor, by means of a spectroscope placed at the near end of the tube. Careful precautions were taken to shut off all direct radiation from the walls of the porcelain tube to the slit of the collimator.

On thus heating sodium carbonate and sodium chloride it was found that *the highest available temperature of the furnace failed to give the slightest trace of the D lines in either the emission or absorption spectrum.*

Metallic sodium, on the contrary, showed the D lines in both spectra. Mr. Pringsheim thinks, however, that it is quite impossible to prepare, at present, any of the neutral gases so free from oxygen that the spectroscope will not detect some chemical reaction with metallic sodium. The results just given are equally true whether the substances are heated in nitrogen, carbon dioxide or air.

The next step was to heat these salts in one of the so-called "cold flames." A mixture of carbon bisulphide and air was chosen. This flame can be ignited by a glass rod heated to 149° C. The temperature of the flame was varied, (by changing the proportions of the mixture,) until the characteristic spectrum of sodium was just visible in a direct-vision spectroscope of small dispersion. The temperatures of the porcelain tube and of this flame were measured by a Platinum—Palladium couple.

The result was that sodium *salts* gave the two yellow lines in the flame at temperatures at which not the faintest trace of luminosity could be detected when the same salts were heated in neutral gases.

The natural conclusion is that the luminosity of sodium chloride in flames is due to some form of energy other than that of heat, probably chemical. The following variations were introduced to find if possible what this chemical action might be. The fact that sodium salts, when heated in a closed porcelain tube filled with air, do not become luminous would seem to indicate that the chemical process is, at least, *not* one of oxidation. Reducing agents were, therefore, tried. The four-way stop-cock mentioned above was connected by one outlet to a supply of hydrogen, by another to a supply of coal gas. It was then found that a large number of sodium salts—all, indeed, that were tried—when heated in an atmosphere of either of these gases gave the usual emission and absorption spectra.

On pumping out the hydrogen, or illuminating gas, these spectra diminished greatly in intensity. The introduction of air, in place of hydrogen, sufficed to entirely quench all luminous radiation.

A bit of charcoal introduced along with the neutral gases would bring out the sodium lines. A small piece of iron had the same effect.

In every case, it will be observed, the presence of a reducing agent appears to produce luminous radiation. The fact that charcoal in the presence of air does not have this effect is evidently because the carbon is all used up on the oxygen in the air. In the ordinary Bunsen flame, therefore, it would appear that the molecules of the salt are not broken up by oxidation, nor yet by dissociation due to heat, but rather in consequence of reduction by illuminating gas and carbon monoxide.

If this view be correct,—and it is not an entirely new* one,—one would expect that the introduction of Na_2CO_3 into the heated tube filled with hydrogen would bring the sodium lines suddenly into view. The withdrawal of the sodium salt ought then to make these lines as suddenly disappear.

This test was accordingly made with several gases. For placing the substance in the heated part of the tube quickly, an iron spoon was used. The salt was placed in this spoon before the tube was sealed up.

An electro-magnet was used to draw the loaded spoon alternately into and out of the heated portion.

The results are indicated in the accompanying figure:

Hydrogen.

Since the porcelain tube, except when used for the first time, is always covered with a glaze of sodium silicate the mere introduction of hydrogen sets up a process of reduction which gives the D lines as pictured in *fig. a*.

The same thing happens when the iron spoon remains in the cold part of the tube. If now the salt be drawn into the hot portion of the tube, the spectrum suddenly assumes the appear-

* Vogel: *Spectralanalyse irdis:her Stoffe. p. 104.*

ance of *fig. b.* On withdrawing the salt the spectrum *immediately* returns to *fig. a.*

Carbon dioxide.

In this gas, the D lines cannot be seen at all until the sodium carbonate is pushed into the hot part; they then show themselves as in *fig. c*: but, on withdrawing the salt, they do not disappear completely, but become sharp as in *fig. e.*

Air.

In air, there is no spectrum seen until the salt is drawn into the region of high temperature, when *fig. d* represents the appearance. As soon as the carbonate is drawn out the spectrum disappears completely.

The trend of these experiments is evident. They were intended to furnish an answer to this question: Does the vapor of a salt, having been broken up into its chemical constituent atoms by means of a reducing agent, become luminous by the heat alone or is the luminosity due to the chemical reaction? If it be due to heat alone, the spectrum of the vapor in the heated tube should disappear more or less *gradually* when the remaining solid salt is withdrawn. Such, however, is the case only with carbon dioxide in which the spectrum drops gradually from *c* to *e*. And this, the author thinks is only an apparent anomaly. But the chemical explanation which he offers does not appear perfectly satisfactory.

The outcome of the whole matter is that Mr. Pringsheim's experiments have made it highly probable that gases become luminous only at the moment of some chemical change. Indeed, as Siemens pointed out more than ten years ago, we have as yet no evidence that any gas will radiate light in consequence of high heating.

As to the case of the electric spark and the Geissler tube, these are confessedly complicated by electrical phenomena which are, at present, inseparably connected with the heating effect. The recent and numerous experimental verifications of the electromagnetic theory of light and the exceedingly low temperature of the Geissler tube both lead one to think that the luminosity of the spark may owe more to electrical than to purely thermal processes.

The author closes with the interesting remark that his experiments show in a *qualitative* way, at least, just the phenomena

which one might predict from Kirchhoff's Law, *yet without satisfying the conditions of that law.* The classical mechanical explanation, resonance, is the one offered. Following is Mr. Pringsheim's own summary:

(*1.*) *There are no luminous gases known which satisfy the conditions of Kirchhoff's Law.*

(*2.*) *It is possible to produce luminous gases whose temperatures fall below 150° C.*

(*3.*) *Sodium salts, in flames, become luminous only in consequence of chemical processes.*

(*4.*) *Metallic sodium, heated in neutral gases, is luminous only in consequence of chemical processes.*

(*5.*) *The assumption that gases can become luminous by mere increase of temperature is an hypothesis, demanded neither by experiment nor by theory.*

This piece of work strikes one as having been very carefully and skillfully performed. But the author will probably find some of his deductions questioned. For instance, it will be remembered that Mr. Pringsheim measures his temperatures with a thermopile whose dimensions, compared with the size of the flame, are small be sure; but, when compared with molecular sizes and distances, they are practically infinite. So that he uses what one might style an "integrating thermometer." May not the temperature, developed in the immediate vicinity of those molecules in which chemical action (reduction) is going on, be very much higher than that registered on the thermopile? Is it not possible that local temperatures thus produced in cold flames may give rise to intramolecular* motions which are sufficient to produce radiation? Wüllner has shown that this is what actually happens in Geissler tubes when the pressure exceeds a certain fraction of one atmosphere. A rotating mirror shows that only slender filaments of the gas are heated at each passage of the spark. So that, in two tubes where the amount of heat generated per second is the same in each, the local temperature produced by the sharp linear discharge *appears* to be much higher than those produced in the low pressure tubes where the discharge is diffuse. May it not be the same with chemical reactions in the flame?

This is by no means the first time that doubt has been cast upon Kirchhoff's Law. See Schuster's article on *Spectroscopy* in the

* I take it for granted that light is due rather to the relative motions of the parts of the molecule, than the motion of the molecule as a whole. On any other supposition, one would find the utmost difficulty in explaining the large number of spectral lines produced by single substances.

Encyclopedia Britannica where he sets forth some experimental evidence for thinking that this law does not tell the whole story. See also E. Wiedemann's paper on the Mechanics of Light (Wied. Ann., Bd. 37, p. 185), where, after pointing out the limitations of the law, he distinctly avows his belief that it holds "for an ideal case only."

LICK OBSERVATORY, 18th of May, 1892.

NOTES ON THE SPECTRA OF SUN-SPOTS.*

A. L. CORTIE.

As we have now arrived at a period in the Sun-spot cycle, when large spots may be expected to be frequently seen on the Sun, it may be well to call the attention of solar observers to some lines in the red end of the spectrum which the experience of the Stonyhurst observers has so far shown to be much widened in the spectrum of large spots. Many of these lines are faint lines, not recorded by Angström in his map, and accordingly require a high dispersion for their detection. The wave-lengths of lines which are given in the present paper are taken from a magnificent set of prints from enlarged positives of the region D to λ 6677, which have recently been presented to the writer by Mr. George Higgs of Liverpool, as specimens of the photographic studies of the normal solar spectrum on which he is at present engaged. These prints are on about one-third the scale of Professor Rowland's well-known maps, and are founded upon his wave-lengths. A careful comparison of the two maps over the region indicated has shown a perfect agreement in the wave-length numbers, so that possessors of Rowland's maps will be easily able to identify the lines presently to be mentioned. Much use, also, has been made of Mr. McClean's excellent comparative photographic spectra of the high and low Sun lately presented by him to the Stonyhurst Observatory. In the observations of Sun-spot spectra made at Stonyhurst, the full battery of twelve prisms of 60° in a Browning automatic spectroscope is generally employed.

Our plan will be to follow the spectrum from D to C, and to call attention to some salient points as we advance. For these notes are by no means intended to be exhaustive, but rather typical of what may be seen by a diligent observer,

* Communicated by the author.

even in this small portion of the solar spectrum. We begin with a double at λ 5978.0 and λ 5978.8, the former of which lines both Thollon's and McClean's maps show to be an air line, while the latter is a faint titanium line. A peculiarity noted in this line in Sun-spot spectra is that it is one of those which are most affected in the penumbra of spots. At times it has been traced as a widened line to a considerable distance on the disc. At λ 6042.4, 6056.2, 6065.8 and 6078.8 are four well-marked iron lines. Each of these lines is preceded by some faint lines of which λ 6040.0, 6053.95, 6063.1, 6077.1 are the most conspicuous. All these lines are solar lines, as both the maps of Thollon and McClean give them of the same intensity in both high and low Sun. Of the four faint companion lines to the iron lines Angström only draws one, a line in his map corresponding to λ 6077.1. Yet this line is the faintest of the four, and my own experience is corroborated by the photographs of Higgs and McClean, and, except perhaps for the line λ 6040.0, by Rowland's chart. These faint lines are remarkably and persistently widened in Sun-spots, irrespective of size or period in the cycle.

Between the line 6079.2 and the triplet at 6102.9, of which the outer components are due to iron and the middle line to calcium according to Thollon, thus furnishing one among many examples of the resolution of a "basic" line, occurs a group of faint solar lines, the number of lines in which has been variously estimated by different observers. Of these faint lines two are due to iron, and two to titanium, the line of this latter metal at 6088.05 being frequently very much widened. At λ 6160.95 and 6161.4 occurs a double of which either one or both components are due to sodium. It just precedes a dark calcium line at 6162.3. If a moderate dispersion be employed these three lines will form but one and will be found to be greatly widened in spots. But when the three lines are separated by higher dispersion the widening in general is seen to be principally due to the sodium lines, which present at times quite the appearance of a fuzzy band.

The next point of interest is to be found in the neighborhood of the fine double iron line at λ 6191.4 and 91.7, which is followed by another strong iron line at 6200.5. In the intervening space the map of Thollon gives two groups each of three faint lines, groups which in this instance are rather better seen in Rowland's than in Higgs' map. The first of these groups ends with a line at λ 6196.4, and the second has a mean position at about λ 6199.5. In the instrument I have employed each of these groups has

appeared as a single faint line, and of these the line representing the group at mean position 6199.5 has been very much widened. A fairly strong line at λ 6204.9 is also conspicuous in Sun-spots.

The group of lines extending between λ 6230 and the head of the α band contains several strong iron lines and a titanium line. These iron lines, especially those on each side of the comparatively bright gap in the spectrum, whether due to contrast or really bright, at 6250 are much widened in Sun-spots. It is to be noticed, however, that the strong lines at 6252.8, 54.3, and 56.4 are preceded by faint companions. Although I can just separate these companions from the stronger lines, in spots the widening is as of single lines, and it is not at all unlikely, from analogy with other parts of the spectrum, that the greater share of the widening may be due to these faint lines. A greater dispersion should show this. The question often arises as to whether changes have occurred in the solar spectrum since it has been studied and mapped with care. Comparison with Angström's normal maps brings to light several discrepancies with what is now to be seen in this portion of the spectrum. As an example we will select a fairly strong line which Angström draws, and which Burton in the British Association Catalogue for 1878 places at 6262.68, but for which he gives no intensity or width. On Rowland's scale the position of the line would be about 6263.68, but at this position there is no trace of a line either on his or Higgs' maps. I have looked for the line several times and have failed to see it. The only possible lines which occur between 6261.3 and 6265.3, the places of two other strong lines, are three faint lines, partly solar and partly atmospheric, which occur on Thollon's maps, Plate VI, No. 12, at scale readings 307.77, 308.43, and 310.38. These faint lines do not seem to be in Rowland's map; there is a slight suspicion of something at 6262.5 in a photograph of Higgs', solar altitude 48°, and a line is to be seen somewhat in this position in McClean's low Sun photograph. Either Angström made a mistake, or it may be possible that his strong line is represented by these approximately near faint lines.

But of all the Sun-spot lines in this region the most remarkable for widening is a faint line given by Rowland and Higgs at 6243.2 preceded by a very faint line at 6243.0. Angström does not give either line. The appearance of 6244.0 in Sun-spots led me to suspect the presence of 6243.2 in the solar spectrum. For at times 6244.0 seemed just as if it had been pricked on the

more refrangible side and a bead of black matter had exuded. Either then 6244.0 was very much displaced, or the bead was due to the widening of a fainter line which I had so far failed to trace in the solar spectrum. The latter turned out to be the correct explanation. This line is on Thollon's chart at Plate VII, No. 13, scale reading 63.44, while the still fainter line at 6243.0 is at scale-reading 64.70. The lines are solar, for Thollon draws them of the same intensity throughout the four horizons of his map, and 6243.2 is also of the same intensity in McClean's high and low Sun photographs. My dispersion does not show me whether the widening is wholly attributable to 6243.2 or to this line and 6243.0 conjointly. On flashing a Sun-spot across the slit of a grating spectrometer of 14,438 lines to the inch and using the second order, it was possible to see that both these lines were widened.

The α band is full of very interesting details in Sun-spots, although it is greatly complicated by the presence of atmospheric lines. And this leads to a remark with regard to the possible cause of the widened appearance of telluric lines in Sun-spots, for such lines are to be seen among the lines thus affected by spots. When a fuzzy set of telluric lines are seen across a spot, one optical effect is that of widening, although, except in the case of bands of lines, this is not very marked. But the case we are considering is that of isolated telluric lines which are seen widened even when the Sun is at a good altitude above the horizon. This is probably due to the presence of a solar line so close to the air line that none but the greatest dispersion will separate them. Of such a composite nature is probably the line between the D lines at 5891.9 often seen widened in Sun-spots. The nickel line too between the D lines has a telluric companion so close that in a photograph of Higgs of the E and W limbs of the Sun, they form one line on the W limb picture, and are well separated on that of the E limb. In fact this observer has suggested the observing of telluric lines in Sun-spots as a further means, in addition to that of observing the lines for intensity at various solar altitudes, for determining the presence of faint solar lines which are exceedingly close to air lines. But to return to the α band. The two lines at 6305.95 and 6306.8 would well repay attention. Higgs' photographs of this portion of the spectrum are superb, especially one taken with a low Sun. With regard to these two lines a comparison of the observer's high and low Sun pictures show that they are at least in part due to our atmosphere. They are much darker, too, in McClean's low than in his high Sun photograph.

XUM

Turning now to Thollon, the lines are at scale-readings 139.96 corresponding to λ 6305.95, and 137.05 corresponding to λ 6306.8, on Plate VI, No. 12. But while 6305.95 is continued to the fourth horizon, showing that it is partly solar in origin, 6306.8 is terminated in the third horizon, indicating a purely telluric line. In the *Bulletin Astronomique*, Vol. I, p. 74, will be found a study by M. Cornu of the rays of this band, in which these two lines are attributed to oxygen in the Earth's atmosphere. Mr. Higgs also independently was led by his studies to attribute them to the same source. Curiously enough I too, before I had consulted any of these maps or Cornu's memoir, found that while 6305.95 was very greatly widened in some Sun-spots, 6306.8 was not widened at all. In Cornu's paper his method is described of determining the solar or atmospheric character of a line by oscillating the solar image across the slit. His result is that both these lines are air lines, and due to oxygen, thus differing from Thollon, who draws one as partly due to the Sun, which one was independently seen widened in Sun-spots. Is it possible, then, that there is a line in the Sun so close to the position of an oxygen line in our air, that neither Cornu's oscillation method nor the great dispersions of Thollon, Rowland and Higgs will separate them? With regard to the widening, however, it is just possible that a very faint line which Thollon gives at scale-reading 142.03, and which is λ 6305.6 on Higgs' and Rowland's maps, may, with the dispersion I employ, have some part in the result.

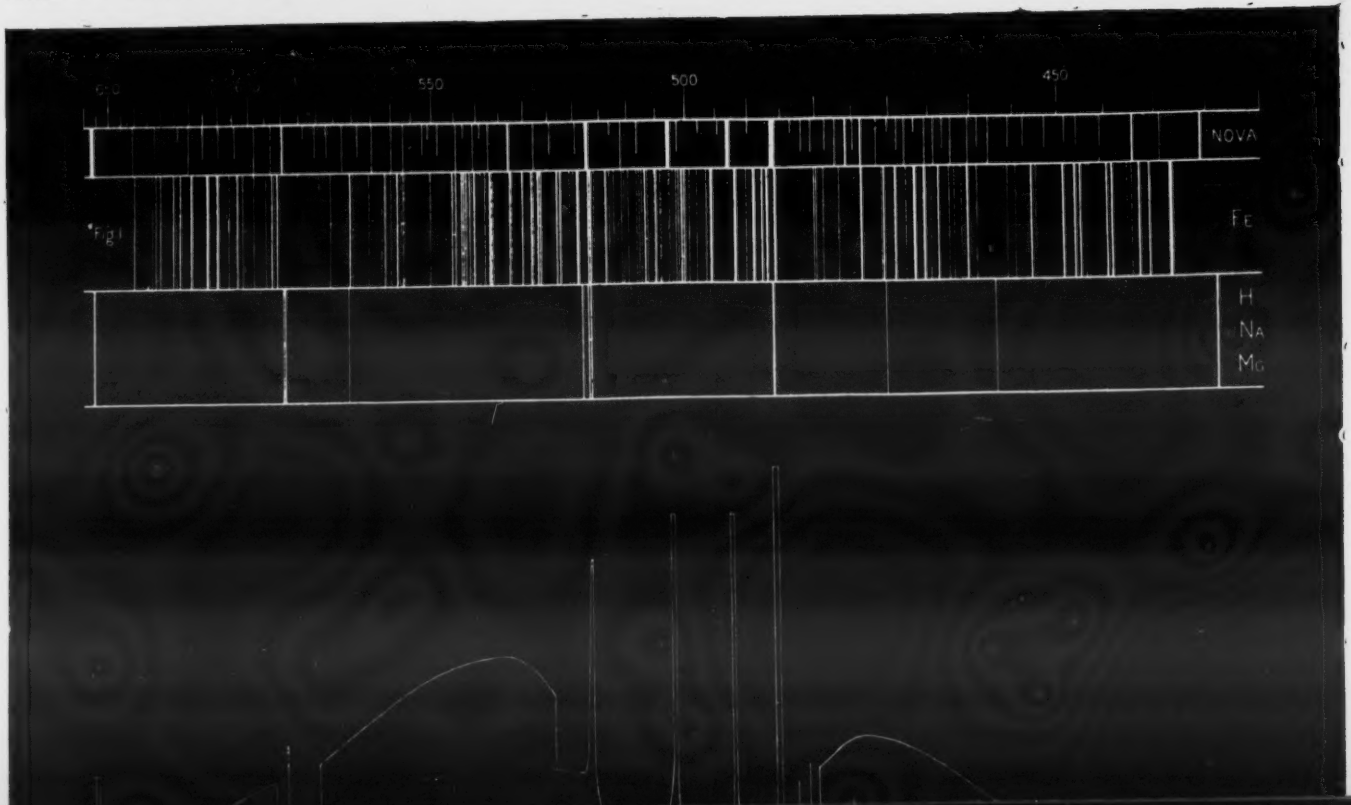
Telluric lines complicate the spectrum from this to C. For instance there is a group of five lines extending from 6361.05 to 6363.05, of which, as Mr. Higgs informs me, the first, fourth and fifth are solar, and the second and third are air lines. On Rowland's maps the three solar lines are well given, while McClean's map brings out the fact very well that the group is much darker in the low Sun. Yet Thollon, in Plate VI, No. 11, readings 254.47 to 246.92, draws them all of the same intensity throughout, so that according to this observer they are purely solar lines. In the large Sun-spot of September, 1891, I found the three solar lines affected, while the other two were not. Among the five lines is an example of a variable line at 5362.6, a zinc line which according to Mr. Lockyer had dropped out of the solar spectrum in 1873, although it was present in Kirchhoff's time. Angström has it at 6361.16, so has Burton, Rowland, Higgs, Thollon; so too probably has Fievez at 6361.2, and Piazzi Smyth. It was therefore in the Sun in 1861, 1868, 1878, 1882, 1884, 1888, and we may say ever since. In 1873 it had gone.

XUM

The region from this on to C is one that is very rich in spectroscopic details. There are several chromospheric lines of Young's catalogue to be found here, some strong iron and calcium lines at times much affected in spots, and also some faint lines which will well repay study. At λ 6415.2 and 6417.1 are two lines which I have observed on more than one occasion to be obliterated when they crossed a spot. This too is the region where the spot-bands were seen, similar to those previously discovered by Young and Maunder. The evidence so far collected would seem to indicate that their appearances in the spot-spectra are to be looked for at that period of the spot cycle when the curve has attained its maximum and has commenced its decline. Although my own observations since 1889 have been somewhat desultory, yet in such observations as I have been able to make I have not seen these bands since the well-marked drops in the Sun-spot curve in 1886.

In large Sun-spots the C line is always an object of interest, and no very great dispersion is needed to observe its changes. The Stonyhurst observations would seem to show that in spots, or in their neighborhood, it is generally when not reversed less dark, or if widened, only slightly so. Reversals too are to be expected both in the umbra and in the penumbra, and in the faculæ surrounding spots. In this connection we would offer in concluding these notes a remark with regard to the interesting observations of Professor Hale and Dr. Crew on the C line in the big spot of February, 1892. (ASTRONOMY AND ASTRO-PHYSICS, April, 1892.) Considering the difference in dispersion employed by the American observers and by myself I am induced to think that the appearance which I observed in the spot of September, 1891, and which was reported in the "*Observatory*" for November, 1891, as a thin hair-like line adhering to the C line, turned towards the red, and forming an angle of about 30° with the C line, was a very similar appearance to that observed by Dr. Crew and Professor Hale in the February, 1892, spot. With regard too to the lines, possibly three on Rowland's map, which occur between C and the iron line at λ 6569.3, and across some of which the appearance extended, both Higgs' photographs and Thollon's maps show altogether seven lines. Two of these are quite close up to C, and one of them is well shown on Rowland's map. Of the other five one is slightly in advance of the iron line. The four remaining lines are very faint lines given by Thollon, Plate V, No. 9, between the readings 181.98 and 190.98, and drawn of equal intensity in all four horizons, thus indicating their purely solar origin. But while on Higgs' maps three of these four lines are

PLATE 23.—SPECTRUM, INTENSITY-CURVE AND MAGNITUDES OF NOVA AURIGÆ, 1892.



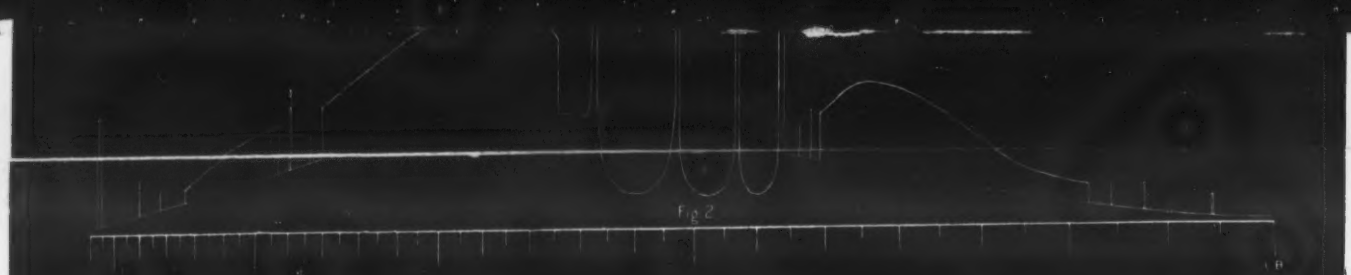
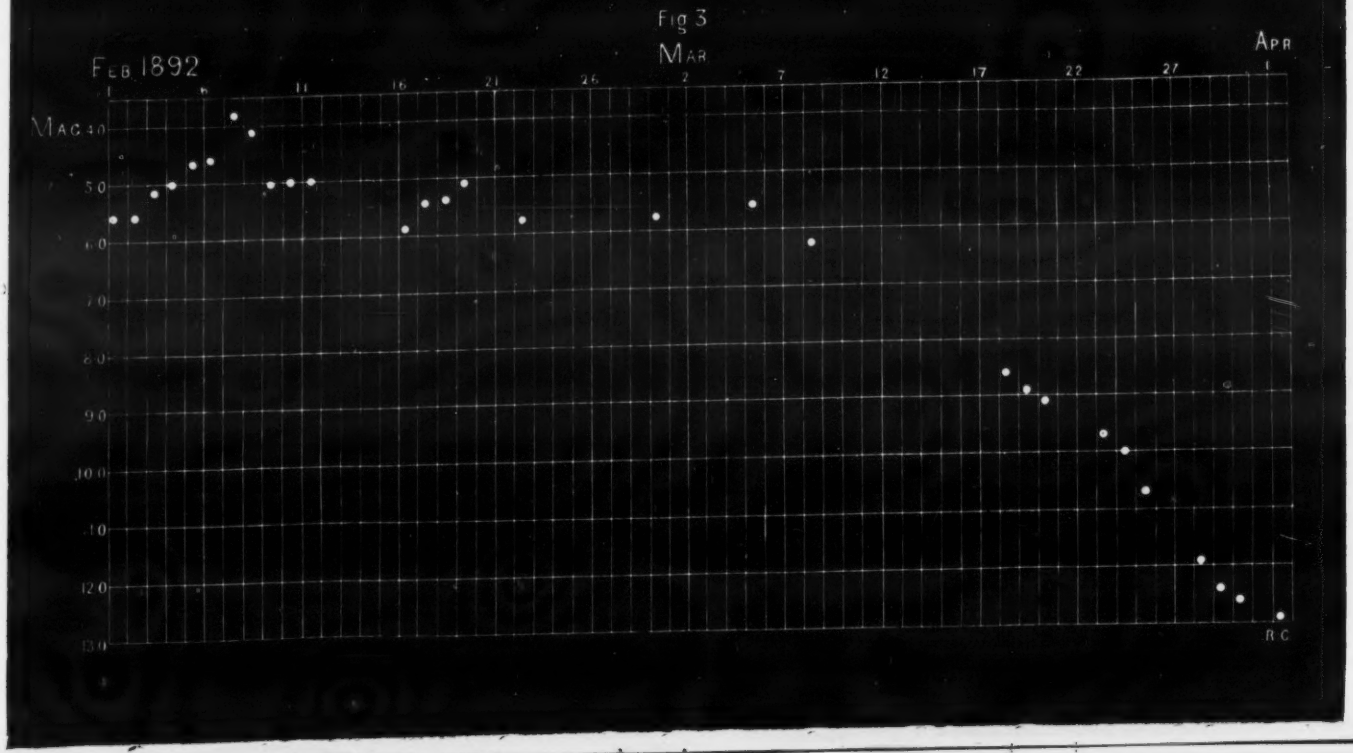


Fig 2

Fig 3


FEB 1892
MAR
APR
1
6
11
16
21
26
2
7
12
17
22
27
MAG
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
R C

just traceable at solar altitude 45°, the same three are well marked and the fourth is visible at solar altitude 13°. Referring to McClean there are no lines between C and the iron line in the high Sun photograph, but the three well marked lines of Higg's low Sun photograph are also quite black and conspicuous in McClean's low Sun map. Photography would then indicate that these lines are partially, if not wholly, air lines.

STONYHURST OBSERVATORY, April 22, 1892.

ON THE NEW STAR IN THE CONSTELLATION AURIGA.*

PROFESSOR RALPH COPELAND, ASTRONOMER ROYAL FOR SCOTLAND.

Together with Observations of the Same by Dr. L. Becker.

(Read 15th February, 1892.)

The discoverer of Nova Aurigæ is the Rev. Thomas D. Anderson of Edinburgh, D. Sc. in Classical Philology. Dr. Anderson is "almost certain" that he saw the star at 2 A. M. on January 24 of this year; it was then slightly brighter than χ Aurigæ. Unfortunately he mistook it for 26 Aurigæ, which it precedes by about $6^m\ 39^s$, merely remarking to himself that the star was brighter than he had previously thought it to be. Twice in the following week he made the same observation at about the same hour of the night. At last on the morning of January 31, it flashed upon him that, after all, the star was not 26 Aurigæ, and that 26 Aurigæ had a much greater right ascension. He consulted a small star map, and the discovery was made. Regretting that he had not earlier compared the map with the heavens, and thinking that the star might be well known to astronomers, Dr. Anderson wrote an anonymous post card to me on the same morning bearing the words: "Nova in Auriga. In Milky Way, about two degrees south of χ Aurigæ, preceding 26 Aurigæ. Fifth magnitude, slightly brighter than χ." I may add that Dr. Anderson's plant consists of a small hand spyglass adapted to astronomical purposes by removing the front pair of lenses from the eyepiece. In this state it magnifies about ten times, and, of course, gives inverted images. Dr. Anderson hopes that amateurs, although provided with only the most modest appliances, may, by his unexpected success, be induced to persevere in their observations.

I have examined a large number of star maps and catalogues,

* Communicated by the author, by permission of the Royal Society of Edinburgh.

ancient and modern, without finding any previous record of the new star. Several stars are mentioned by Sufi as being visible in the tenth century which we cannot now identify, but they seem certainly to have no connection with the Nova. The two stars named "the Shaker," and "the excellent Milch Camel" may, however, possibly be identified by a study of certain Arabian authors referred to by Sufi.

As to our observations of the Nova at the Royal Observatory, its place has been found by differential methods by Mr. Heath, First Assistant Astronomer, using the transit instrument, and by Mr. J. A. Ramsey, student of astronomy, observing with the Mural Circle. The mean coördinates for 1892.0 derived by them are:—

R. A. $= 5^h\ 25^m\ 3^s.25 \pm 0^s.02$ (9 obs.).
Decl. $= +30°\ 21'\ 48''.76 \pm 0''.09$. (7 obs.).

Already on the night of February 1, a small spectroscope revealed the presence of bright lines, of which some account was at once telegraphed to the Central Station for Astronomical Telegrams at Kiel, and also to the President of the British Association, Dr. W. Huggins. Already in the daytime, before the star was visible, a message had been forwarded to Greenwich Observatory.

The remarkable nature of the star's spectrum once established, Dr. Becker immediately set about packing the most suitable apparatus to take to Dunecht, where the 15-inch refractor is fortunately still in perfect adjustment. Meanwhile I arranged to keep a record of the stars magnitude, and try what could be done with the apparatus at Calton Hill. Owing to the great loss of light in the universal spectroscope of the 24-inch reflector, it soon became evident that only a few of the very brightest lines of the spectrum could be measured therewith, while it was impossible when using it to obtain a good general idea of the spectrum and its possible changes. Eventually I returned to a small instrument of Vogel's pattern, which had proved useful on former occasions.* With it were obtained on February 9, a set of measures which eventually yielded the following rough approximations to the positions of the principal bright lines in the spectrum of the Nova:—

* See *Copernicus*, vol. ii. p. 105, for a description of this instrument.

Wave-length. mmm.	Relative Brightness.	Remarks.
657.1	10	*C.*
645	...	Edge of black band extending from *C.*
594.2	2	Possibly an inaccurate place of D.
562.1	3	
534.5	6	
519.3	10	Possibly carbon band or magnesium.
503.2	5	Bright band near nebular line but not identical therewith.
495.25	3	Near nebular line, but also distinct therefrom.
487.1	4	*F.*
450.8	1	Extremely faint; place very uncertain.

Respecting the brightness or "magnitude" of the star there is a telegram from Professor Pickering of Harvard College, Cambridge, Mass., dated February 5:— "Nova bright on photograph December tenth, faint December first, maximum December twenty, spectrum unique." This is understood to mean that the star could be detected on a photograph taken on December 1, that it was brighter on December 10, and brighter still on December 20. At least this is the very probable reading offered by Professor Krueger of Kiel. So far as is known, there is no certain record of the star's having been seen or photographed previous to December 1, 1891. A faint star seen by Krueger near to the spot, 1858, March 23, in one of the revisional zones of Argelander's Atlas, has been identified in the heavens near to the Nova. Then we have Dr. Anderson's observations, Jan. 23 to January 30—Nova slightly brighter than χ Aurigæ, 4.8 magnitude.

From February 1 to 11, I have a complete set of estimations. These indicate a maximum about the 7th or 8th. [Compare the curve in fig. 3 and the table on page 2, which have been extended so as to include the subsequent observations.] Not one of the four Novæ of modern times has exhibited a curve of this character, at least as far as one can judge from the present available data for Nova Aurigæ.

From Dr. Becker I have received the most satisfactory results, derived from observations made on February 3, 4, and 5, and again on the 10th and 11th. [These results were exhibited to the Society in a graphic form, but it is here preferable to give Dr. Becker's written account of the observations as received from him on February 16.]

Observations of the Bright Lines in the Spectrum of Nova Aurigæ, made at Dunecht by Dr. L. BECKER.

The day after the discovery of the new star was announced, I left for Dunecht Observatory in order to observe its spectrum with the 15-inch refractor. The large spectroscope by Cooke,

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with a collimator 24 inches in length, having already been removed to Edinburgh, I employed in my observations the smaller spectroscope by Grubb, the same with which Professor Copeland had made the greater part of his former observations. The collimator of this instrument has 7 inches focal length, and an effective pencil of light 0.6 inch in diameter; the viewer is 10 inches in length, and turns by a worm-screw with a divided head working against a sector which can be clamped to the prism-box. The prism is kept in a fixed position. In these observations a compound prism was used at the minimum deviation for *b*. On the first night, February 3, a power of 14 diameters was used but on the following nights one of 7. For comparison I employed the sodium and lithium lines, and the lines of the zinc-lead spark spectrum, as produced by a five inch induction coil in connection with a Leyden-jar. The light from the spark passes through a lens, and is reflected to the upper and lower part of the slit by a small silver mirror, which is fixed in front of the slit and has an opening for allowing the light from the object-glass to pass. The same battery which works the coil serves to illuminate the field of view by reflection from the last surface of the prism, and also to produce bright wire illumination. By means of a small rheostat, which is clamped to the sector, the light may be moderated, while a switch enables the observer to put either the incandescent lamps or the coil into circuit. This arrangement, which I introduced in the last weeks of my stay at Dunecht in 1889, is very convenient if the observer has to observe without assistance. In reducing the observations to wave-lengths (Potsdam system) I first determined, once for all, 4 constants of Ketteler's formula of dispersion from measures of four solar lines equidistant between A and H, and computed a table giving the wave-length as a function of the readings of the screw. The deviations of this curve from the one given by the observations of solar lines are so small that they may be determined with great accuracy by the graphical method. The lines of the spark spectrum were measured along with the solar lines, the latter being at the center part of the slit, the former below and above. Although the values of their wave-lengths thus determined are erroneous by the amount of curvature of the lines, they have to be employed in the reductions of the star observations in order to reduce the lines of the stellar spectrum to wave-lengths.

In the night observations I measured at the beginning and end of each set the prominent spark-lines in the part of the spectrum under observation, always turning the screw in such a manner that the viewer moved opposite to the direction of gravity.

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Their readings thus being known, I could then also pick them up while observing the stellar lines without being obliged to turn the screw in the opposite direction. The first observations serve to correct the reduction-table, the second to determine the changes of the zero point. Since the spectroscope is not rigid enough for taking several pointings of one line, without observing each time the spark spectrum, I measured through one region of the stellar spectrum without turning back. For this reason all the observations of any one line are quite independent. Almost all the measures were taken in bright field illumination. It is needless to say that the observations of most of the lines were very difficult, but I have not the least doubt that those repeatedly observed refer to real bright lines, and are not merely an effect of contrast produced by dark lines on the continuous spectrum. There are 302 observations, belonging to 71 lines, made on February 3, 4, 5, 10 and 11. Afterwards I made arrangements for photographing the spectrum, but the sky did not clear up before my return to Edinburgh.

The mean values of the wave-lengths λ and their intensity I (where 1 stands for faint, 6 for very bright) are:

1892.	No. of Obs.	λ	I	1892.	No. of Obs.	λ	I
Feb. 4, 5, 10	5	657.0	5	Feb. 4, 5	5	540.7	3
" 3, 4, 10	5	642.5	3	" 5	1	539 ±	1
" 4, 5, 10	4	632.5	2	" 4, 5	6	537.4*d*	3
" 5, 10	2	624 ±	1	" 3, 4, 5	6	533.0*	4
" 4, 10	3	620.3	2	" 3, 4, 5	5	528.0	3
" 3, 5, 10	6	615.1	2	" 3, 4, 5	6	524.6	2
" 3, 4, 5, 10	5	609.9	2	" 3, 5	3	519.6	2
" 3, 5, 10	7	604.7	2	" 3, 4, 5, 11	8	517.45 ± 0.12†	5
" 3, 4, 5, 10	7	598.5	3	" 3	1	513 ±	1
" 3, 4, 5, 10	8	593.4	3	" 3, 4, 11	4	511.1	2
" 3, 4, 5	13	589.7 ± 0.15	4	" 3, 4	2	508.2	2
" 3, 4, 5	4	583.8	1	" 3, 4, 5, 11	6	502.68±0.11‡	5
" 3, 5	3	580.5	2	" 4	1	501 ±	2
" 4, 5	3	577.1	2	" 4, 11	2	497.9	1
" 4, 5	3	572.9	3	" 3, 4,	2	494.7	1
" 3, 4, 5	4	568.7	2	" 3, 4, 5, 10, 11	6	493.17±0.17‡	5
" 3, 4, 5	4	564.9	3	" 3	1	490 ±	1
" 3, 4, 5	5	560.0	3	" 3, 4, 5, 10, 11	9	486.88±0.08‡	6
" 3, 4, 5	6	557.0	3	" 10	1	483.6	1
" 3, 5	5	552.4	2	" 3, 4, 5, 10, 11	6	482.0	2
" 4	2	551.0	1	" 4, 5	2	480.7	2
" 3, 4	3	548.8	2	" 3, 4, 10	3	478.8	2
" 3, 4, 5	6	544.6	3	" 4, 5, 10, 11	6	477.4§	3
" 4	1	543 ±	1	" 4, 5, 10	4	475.7	4

* Many close lines in this part of the spectrum, of which this is the most prominent.

† On Feb. 10 it was recorded that the bright line 517.4 was very broad, and that the intensity fell off gradually towards the red, while it was cut off abruptly at the more refrangible edge.

‡ It was noted on Feb. 3 that the three lines, 502.7, 493.2, and 486.9, "look as if they are double." On Feb. 4 the line 493.2 is entered as the "middle of two lines."

"Dark spaces between the very bright lines" were seen on every night of observation from Feb. 3 to Feb. 11.

§ More lines in this place.

1892.	No. of Obs.	λ	I	1892.	No. of Obs.	λ	I
Feb. 10	2	474·8	2	Feb. 4, 5, 10	6	459·1	2
" 3, 4, 5, 10, 11	7	473·7	4	" 4, 5, 10	9	457·8	3
" 10, 11	5	471·7	3	" 4, 5	3	455·4	2
" 5, 11	2	470·2	1	" 4, 5	4	453·8	2
" 4, 10	3	469·0	2	" 4, 5	3	451·4	2
" 5, 11	3	468·0	2	" 5	1	449·2	1
" 5, 10	3	466·8	1	" 5	2	448·0	2
" 4, 5, 10, 11	6	465·4	3	" 4, 5	3	445·5*d*	3
" 5, 10, 11	5	464·3	3	" 4, 5	5	442·1	4
" 4, 10	4	463·3	2	" 5	3	439·4	3
" 5, 11	3	462·3	3	" 5	4	435·5	4
" 4, 5, 10, 11	5	460·2	3				

The lines marked *d* are double. All the measured lines are shown in fig. 1, where the fainter grades are indicated by shortening the lines. In fig. 2 an attempt has been made to represent the relative intensity of the various parts of the spectrum.

In the spectrum the sodium line (D), and the two hydrogen lines C and F, are present; Hγ is very probably 435.5, which was just at the limit of visibility. All these lines show a decided shift towards the red, from which I find the following velocity of the body per second relatively to the solar system:—

C, +211 miles, D, + 135 (±47) miles, F, 290 (±31) miles.

The very bright line 517.45 lies within the magnesium lines b_1, b_2, b_4, and, considering the shift of the lines, lies close to the iron lines b_3, b_4. However, the great intensity of the line compared with that of the other lines of the spectrum, if iron be supposed to be present, also the gradual falling away of the light towards the red, are in favor of magnesium. The remaining two bright lines are not the nebulous lines.

As the great intensity of the spectrum in the green, due to numerous lines, many of which I was not able to measure, suggests the presence of iron in the Nova, I have entered in the second line of the diagram the most prominent lines of the iron arc-spectrum for the sake of comparison. Although a number of the lines fall together with those of the Nova, one cannot lay much stress upon those coincidences, owing to the great number of lines in iron and the Nova scattered over the whole visible spectrum.

It is noteworthy that some of the brightest lines given above were observed by me at Dunecht in the spectra of R Andromedæ and R Cygni on October 28, 1889, on an intimation by the Rev. T. E. Espin that the F line appeared bright in the spectra of these stars. Although the observations of these stars could not be completed on account of my removing to Edinburgh shortly afterwards, I give the wave-lengths of all the brighter lines in their spectra, all of which, it will be seen, agree closely with prominent lines in the spectrum of the Nova. R Andromedæ was observed the with slit rather open.

R Andromedæ.		R Cygni.		Nova Aurigæ.	
λ	Intensity.	λ	Intensity.	λ	Intensity.
.....	.....	532.3	4	533.0	4
528.6	3	528.9	3	528.0	3
517.1 *	4	517.0	4	517.4	5
494.5	4	..... †	.....	493.2	5
486.7	6	486.0	6	486.9	6

Postscript added 14th March, 1892.

The new star still continuing bright enough to be observed with the spectroscope, I returned to Dunecht on February 24, but was very unfortunate with the weather. On March 4, I found that the intensity of the spectrum had much decreased, but that the bright lines were still easily seen. From C to 550 I again measured all the brighter lines, while between 550 and F I obtained almost every line that is given above. Thirty-eight lines in all were re-measured, but the results are not combined with those already given. Beyond F the light was too faint for measuring. The results agree with the earlier ones as closely as the size of the spectroscope entitles one to expect. The power 14 was employed. The intensity of some of the lines relatively to each other appeared to be changed. Certainly F was no longer the brightest line, the line 517.5 considerably surpassing any of the others. I was not able to detect any narrow dark lines which had been announced in the meantime, but I measured the middle of the dark spaces to the violet of some of the brightest lines, which formerly I had attributed to the effect of contrast. The wave-lengths of the brightest lines in the green-blue, and their relative intensities (the brightness in February is given in parentheses), were observed as follows:—

Number of Observations.	λ	Intensity.	Remarks.
2	533.4	4 (4)	
2	528.7	4 (3)	
2	524.6	4 (2)	
2	517.5	6 (5)	
2	502.7	5 (5)	Breadth, 0.5
.....	501.2	.....	Middle of dark space; breadth, 2.0.
3	493.0	4 (5)	Dark bands to the red and violet.
5	487.1	4 (6)	
.....	484.8	.....	Middle of dark space; breadth, 3.6.

* A companion on either side 1.5 mmm off. † One very bright line missed (according to note-book) near F towards the red.

Further Remarks on Nova Aurigæ. Professor RALPH COPELAND.

(Communicated 21st March, 1892.)

The most remarkable additional fact that I have to communicate is a sudden diminution in brightness that seems to have set in about the 7th of March. Throughout the month of February the Nova exhibited continual and irregular changes of brightness, which are shown by the dots in the diagram. The state of the sky was unusually favorable during the earlier part of February, and later on still offered occasional opportunities of comparing the star with its neighbors. Unfortunately, on March 8, I had the misfortune to lose the very fine binocular that had up to that time been used in these observations. Hoping that it might be recovered, and not apprehending that any very surprising change in the star's brightness was about to occur, I did not attempt to replace it until the 18th, when, on examining the heavens with a good opera-glass, I was unable to identify the star. It was, however, readily found with a 3¼-inch refractor, but had declined to the 8.6 magnitude. [See fig. 3, and the table on page 601.] On the 19th it had lost a further $0^m.3$, while last night it had so far faded as only to be of the 9.1 magnitude. We thus see that on February 7 the Nova was about 132 times as bright as it was last night. Its brightness on the 8th and 20th are in the ratio of 14 to 1.

Last night, March 20, Nova being about one magnitude brighter than the small star close to it, which was observed at Bonn 34 years ago, it was still practicable to analyse its light with the small spectroscope. The spectrum was strongly continuous in the yellow, green, and blue, with several intenser parts that probably represented bright lines. No trace of the bright C line, formerly so conspicuous, could be made out. It does not seem, at present, that the spectrum is likely to become reduced to a single bright line as was the case with the Nova of 1876, but it seems rather to resemble the continuous spectrum of Nova Coronæ, as it appeared in 1866, when the bright lines were superposed on the continuous spectrum.

Note added April 17.

The further history of this star, as seen in the Edinburgh reflector, is one of steady and continued decline. The magnitudes on the days of observation are given below until April 1, when it was seen for the last time. The place was examined in a hazy sky on April 14, and again on the 18th, when the night was clear,

with the exception of a little inevitable smoke; on neither of these occasions was a trace of the star discernible. Its spectrum was "continuous with traces of dots" on March 25, the star being estimated of the 10.7 magnitude. The brighter magnitudes have been apportioned in accordance with the *Durchmusterung* and some Harvard measures. The fainter part of the scale has been formed on the assumption that the "Bonn star" is $9^m.9$, while the small star, which forms an equilateral triangle with it and the place of the Nova, is set down as $12^m.7$.

On March 28, when it had fallen to $11^m.9$, it could no longer be seen through a prism which gave a distinct spectrum of the neighboring $9^m.9$ Bonn star. Hence we may certainly conclude that on this day the light of Nova Aurigæ was far from monochromatic, or it would have been visible through a prism.

Observed Magnitudes of Nova Aurigæ.

Day.	Hour.	Mag.	Comparison Stars and Remarks.	Inst.
1892	h			
Feb. 1	6.1	5.56	26 Aurigæ; Nova strong yellow. Image strictly stellar afterwards in the 24-in. telescope.	F.G.
" 2	8.1	5.56	26. Nova seen with naked eye.	"
" 3	9.4	5.13	26 and χ Aurigæ.	"
" 4	8.1	5.0	χ.	"
" 5	7.3 to 9.8	4.65	26 and χ.	"
" 6	6.5 and 7.8	4.55	χ.	"
" 7	12.0	3.80	χ, moon very near; Nova seen with unaided eye.	"
" 8	6.0 and 11.1	4.09	26 and χ.	"
" 9	7.8	5.03	26 and χ.	"
" 10	8.8 and 11.1	5.0	26 and χ.	"
" 11	10.0	5.0	χ.	"
" 16	8.3 and 8.8	5.87	26 and D.M. $+30°.898$.	O.G.
" 17	6.9 to 12.2	5.43	26, 898, and χ; Nova certainly brighter than last night.	F.G.
" 18	7.8 to 12.4	5.38	26 and χ.	"
" 19	8.3 and 9.2	5.10	χ.	"
" 22	11.1	5.76	χ.	"
" 29	7.9	5.76	26.	"
Mar. 5	9.6	5.58	χ.	"
" 8	9.7	6.26	26.	O.G.
" 18	8.9 and 9.3	8.58	D.M. $+30°$ 912 and 913.	3¼ in.
" 19	9.8	8.9	913 and $+30°$ 932.	"
" 20	9.0 and 9.5	9.1	913, 932, and Bonn star of 1858.	3¼ and 24 in.
" 23	9.4	9.7	Bonn star.	24 in.
" 24	11.6	10.0	Bonn star.	"
" 25	10.8	10.7	Bonn star and p^* of a pair sf = f.	"
" 28	8.7	11.9	f and faint star of triangle = g.	"
" 29	9.0	12.4	g.	"
" 30	9.0	12.6	g.	"
Apr. 1	9.1	12.9	g and next * to s.	"

The instruments used were F.G., a large field-glass; O.G., two different opera-glasses; a 3¼-inch refractor by Cooke, with a power of 27; and, lastly, the 24-inch Grubb reflector and a power of 138. The silvering of the last-named instrument is at present somewhat thin and imperfect.

THE ULTRA-VIOLET SPECTRUM OF THE SOLAR PROMINENCES.

II.

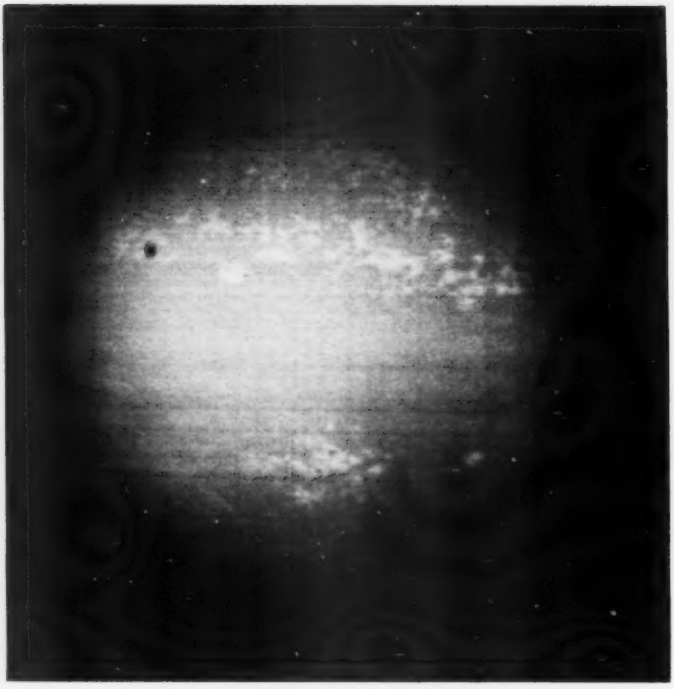
GEORGE E. HALE.

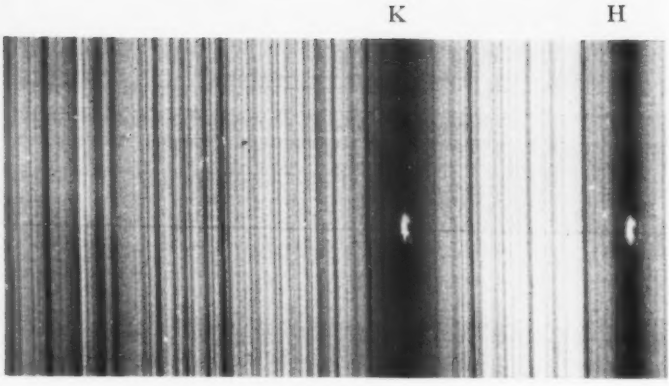
In a paper presented at a meeting of the Paris Academy of Sciences on June 13, 1892, I gave a list of the bright lines obtained in a photograph of the spectrum of a metallic prominence taken at the Kenwood Observatory on May 25, 1892. The photograph shows all lines hitherto discovered in the ultra-violet prominence spectrum (with the exception of a few of the most refrangible, which could not be obtained with the visual objective of the equatorial), and, in addition, four lines not before known. These new lines are marked with an asterisk in the following table:

λ *Lines.*	*Elements.*	λ *Lines.*	*Elements.*
3970.2	Hydrogen (ε)	3835.54	Hydrogen (β_1)
3968.56	Calcium (H)	3832.5	Magnesium
*3961.7	Manganese?	3829.5	"
3933.86	Calcium (K)	3798.1	Hydrogen (γ_1)
*3900.7		3770.8	" (δ_1)
3889.14	Hydrogen (α_1)	3761.4	
3888.73		3759.3	
*3886.4		3750.2	Hydrogen (ε_1)
*3860.0	Iron?	3734.2	" (ζ_1)
3838.4	Magnesium		

A new photographic objective (12 inches aperture) has just been completed by Brashear, and mounted on our equatorial, and by its means I hope to add many new lines to the number now known to be present in the ultra-violet spectrum of metallic prominences.

KENWOOD ASTRO-PHYSICAL OBSERVATORY,
Chicago, July 11, 1892.





Photographs made with the Spectroheliograph of the Kenwood Astro-Physical Observatory, Chicago, by George E. Hale.

1. *Faculæ and Sun-spots.* (*May 21, 1892.*)
2. *H and K Lines in the Spectrum of a Prominence.* (*May 6, 1892.*)

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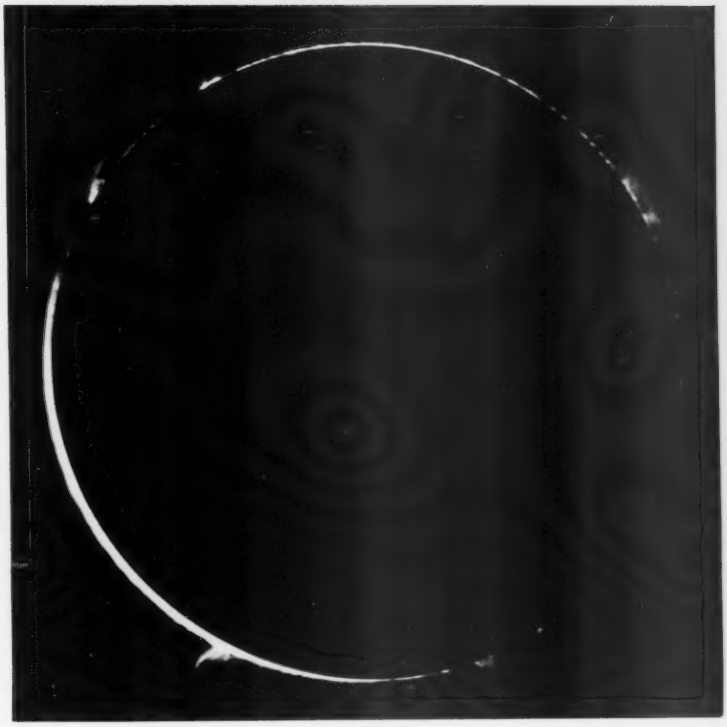

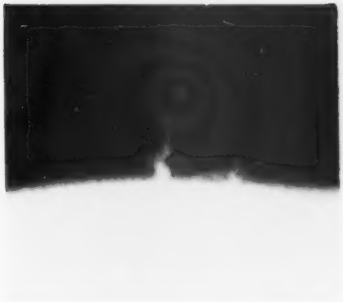

Photographs made with the Spectroheliograph of the Kenwood Astro-Physical Observatory, Chicago, by George E. Hale.

1. *Chromosphere and Prominences.* (*May 21, 1892.*)
2. *Solar Prominence.* (*March 24, 1892.*)

XUM

PHOTOGRAPHS OF SOLAR PHENOMENA OBTAINED WITH THE SPECTROHELIOGRAPH OF THE KENWOOD ASTRO-PHYSICAL OBSERVATORY.

GEORGE E. HALE.

In the May number of ASTRONOMY AND ASTRO-PHYSICS I described the spectroheliograph, and the methods of photographing Sun-spots, faculæ, chromosphere and prominences in daily use at the Kenwood Observatory. The accompanying plates may serve to illustrate the nature of the results obtained. It has been found extremely difficult to reproduce the photographs by the photo-gravure process, and many fine details have unfortunately been lost. This is especially true in the case of the single prominence, which in the original negative is very sharply defined, and shows many faint appendages entirely invisible in the reproduction.

The photograph of the entire chromosphere is strikingly like a picture of the totally eclipsed Sun, taken just at the beginning of totality. In the present case, however, the Moon's place was filled by a circular metallic diaphragm, which was not exactly concentric with the solar image when the exposure was made. This eccentricity accounts for the apparent inequality in the depth of the chromosphere on the opposite limbs of the Sun.

The photograph of faculæ brings out clearly the great importance of this class of solar phenomena. The lack of proper means of observing the faculæ has led us to think of them as of small extent and consequently secondary importance. In fact, observations made in the ordinary way show the faculæ to be no greater in area than the spots. But photographs made by the new method reveal the true state of the solar surface. Instead of merely equalling the spots in area the faculæ are shown to be far more extensive, and in point of size the spots sink into relative insignificance.

In the original negatives made with the spectroheliograph, the faculæ are equally well shown on all parts of the solar surface, but the process of reproduction has so intensified the darkening of the Sun at the limb that the figure in the plate fails to bring out the edges of the disc.

Since these plates were made I have succeeded in making photographs in which the faculæ, spots, chromosphere and prominences are all shown on a single plate in their proper relative positions. This cannot be done with the spectroheliograph in a

single exposure, as the time required to bring out the prominences is much too long for the faculæ. The diaphragm covering the Sun's image at the focus of the equatorial is therefore employed as usual, and the slits are made to move across at the speed required for the prominences. At the end of the stroke the diaphragm is removed, and the slits made to move back over the image at a much higher speed by adjusting the valves of the clepsydra. An image of the Sun's surface, with the faculæ and spots, is thus formed on the plate exactly within the image of the chromosphere formed during the first exposure. The whole operation is completed in less than a minute, and the resulting photographs give the first true pictures of the Sun showing all of the various phenomena at its surface.

KENWOOD ASTRO-PHYSICAL OBSERVATORY,
Chicago, July 11, 1892.

NOVA AURIGÆ.*

WALTER SIDGREAVES.

A short account of the Stonyhurst College Observatory in connection with the subject of this paper will help to explain the long delay in publishing the map of the spectrum of the temporary star in Auriga, and may be of interest to the readers of ASTRONOMY AND ASTRO-PHYSICS, many of whom were well acquainted with its late director, Father Perry.

In pursuance of his desire that stellar spectroscopy should be added to the work of the Observatory, a long series of experiments with three spectroscopes has been carried on during the last two years, with the view of deciding which of them would be the most serviceable, and whether the work could be undertaken with any reasonable hope of contributing to the subject from the small optical power of an eight-inch refractor.

The experiments were commenced with eye observations, using a very superior stellar spectroscope constructed by Mr. Hilger, and fitted with every mechanical aid that could be desired by a spectroscopist struggling to see and to locate barely visible lines in a feeble spectrum. But it was found that only with the best atmospheric conditions for optical calmness any reliable measures could be made, and the eye experiments soon gave place to those of the photographic plate. The plate showed itself com-

* Communicated by the author.

paratively indifferent to the scintillations that troubled the eye, and gave better promise of continuous work.

These experiments included the two methods of giving breadth to the spectrum:—by a cylindrical lens at various positions, and by trailing the star's image over the plate both along the slit and without a slit. They proceeded slowly as each exposure was necessarily long, many repetitions were needed for each adjustment, and the unusual cloudy condition of the sky during the past two years afforded few opportunities for advancing the work.

Eventually the method of trailing without a slit became the one always followed, and the spectroscope selected was a direct vision spectroscope of two compound prisms made by Hilger for service on one of the recent expeditions for observing a solar eclipse. One of the prisms was removed and the reduced dispersion made it possible to obtain an impression of the spectrum of β Lyræ that was quite readable under the microscope.

It was then necessary to find the proper inclination of the plate to suit the focal positions of the series of rays between D and H, the extreme limits of the spectrum obtainable. And this operation occupied all the available nights between the beginning of June and the end of September, 1891. There was not space enough between the extremity of the ocular tube and the position of the focus for a camera provided with an angular adjustment of the plate-holder, and it was necessary to separate the holder from its adapter by a slotted wedge of hard wood. The angle of the wedge was estimated from the measured difference of the focus of *b* and G; but it was found to be much too small, probably on account of the ease with which the eye adapted itself to the different conditions of seeing by green and by blue light. Four wedges had to be tried before the exact angle was obtained. The final result was very satisfactory, the focus appearing uniformly good all along the spectrum from near D to near H.

The angular adjustment of the plate became, by means of the wedge, an unchangeable fixture. And the carrying tube was secured at the position to show G in the middle of the visual field. So that no alteration of the adjustments could be accidentally introduced.

The instrument was thus ready for work four months before the new appearance in Auriga. A number of impressions had been obtained of the spectra of some of the brighter stars, and a series of plates of the variable spectrum of γ Cassiopeiæ. β Lyræ

had also been tried, and the results seemed to show that it would be useless to attempt any smaller star. But no steps had been taken for tabulating the spectral lines to wave-length scale. The observers were waiting for the greater optical power promised by the efforts of a number of gentlemen to benefit the Observatory, to the memory of the late Father Perry, who had lost his life to himself and to it in the cause of its science.*

We are indebted to the kindness of Dr. Huggins for the photograph of the spectrum of the Nova. An early telegram from him, arriving before the Edinburgh circular, gave us the opportunity of the 3rd of February when the star was at its brightest and the sky was exceptionally clear. Two impressions were obtained, and it became necessary to construct a complete map of the details of the spectrum. This required time. No wavelength curve had yet been drawn, and for its construction a sufficient number of solar lines had to be sought and verified on the same small-sized photograph of the spectrum of Capella, or of Arcturus. The solar spectrum itself could not be used, for the same reason that solar light could not be employed in any of the experiments for the accurate adjustment of the slitless stellar spectrograph:—viz., that the spectrograph as used upon the stars without the slit and cylindrical lens is not the same instrument as when provided with the slit for the Sun or planets.†

But eventually an excellent interpolation curve was drawn through forty-two fiducial points obtained from the spectra of Capella and Arcturus, and the two plates of the 3rd February became the subjects of a prolonged and careful study before the map was complete. A catalogue of lines together with the map will appear in the memoirs R. A. S,, and in the accompanying paper some experiments are described, which were instituted to test the reality of the breadth of the lines as shown on the plates and the applicability of the interpolation curve to the spectrum of the Nova. The latter consideration was all important on account of the absence of a slit to direct the incident

* The memorial probably failed to get generally known, and the fund barely reached the figure needed for a 15-inch objective, which had been the desire of the late Father Perry. And we owe much to the generosity of Sir Howard Grubb, who has undertaken to work the glasses and the necessary fittings for the available fund.

† In the latter case the illuminated slit is the object to be focussed on the plate by the lenses of the spectrograph, and is the one position of the object for every color-image on the plate. In the former case the image of the star, as given by the telescope objective, takes the place of the slit. And this is a multiple image forming so many color-objects at different distances from the focussing lenses. The inclination, therefore, of the plate is not the same in the star camera and Sun camera and the two spectra differ in length.

rays to the plate. If the incident angles from the Nova and from the star that furnished the wave-lengths of the curve, were not the same, the two spectra would not be of identical dispersion, and the curve would not suit the Nova. The result was satisfactory, showing that the possibility of the angles being materially different was very small.

The map is a double one: the lower one showing the lines or bands as they are easily seen on the plates, the upper one giving further subdivisions or superpositions, as discovered by a more careful study of the details. Each line in this map has the authority of two examiners, experienced assistants of the late Father Perry, viz., Fr. Cortie and Mr. W. McKeon,—the conditions of acceptance being the evidence of both plates to each examiner.

The object of the paper in the memoirs is to offer the fullest account of the map and catalogue, in order that their value may not be either over-estimated or under-rated. They were completed only a few days before the meeting of the R. A. S. in May; and it was premature to advance any hypothesis to account for the new appearance in Auriga. But it was impossible to omit allusion to an impression which had grown upon us during the construction of the map: that the spectrum was, on the whole, what the solar chromospheric spectrum might be expected to show on a grander scale of disturbance. The general distribution of lines in the two spectra agreed; the richer and the poorer regions being the same in both, and many coincidences appearing amongst them. The breadth of the lines, and the central divisions of F and G′ have also their likenesses in the spectra of our own solar disturbances. Father Fényi, detailing the phenomena observed by him in the region of the great solar spot group of February, says that C "was remarkably widened and had a dark line running through the center." The occasional great displacements of the hydrogen lines over spots are well-known to all students of solar physics, and even the opposite displacements of the bright and dark companions on the Nova's spectrum have had their imitations on solar spot spectra. We may then have to wait till our studies of the solar disturbances are further advanced, to be in a position to interpret correctly the perplexing spectrum of Anderson's new star.

STONYHURST OBSERVATORY,
Lancashire, England.

DISTRIBUTION IN LATITUDE OF SOLAR PHENOMENA OBSERVED AT THE ROYAL OBSERVATORY OF THE ROMAN COLLEGE DURING THE FIRST QUARTER OF 1892.*

P. TACCHINI.

The following results were determined for each zone of 10°, in both hemispheres of the Sun.

1892.	Prominences.		Faculæ.		Spots.		Eruptions.	
90° + 80°	0.000							
80 + 70	0.000							
70 + 60	0.033							
60 + 50	0.080							
50 + 40	0.097	0.536	0.007					
40 + 30	0.116		0.054		0.000			
30 + 20	0.097		0.200	0.480	0.213	0.476		
20 + 10	0.086		0.057		0.213			
10 . 0	0.027		0.062		0.050			
0 − 10	0.043		0.068		0.012		0.000	
10 − 20	0.050		0.212		0.287		0.000	
20 − 30	0.150		0.178	0.520	0.200	0.524	0.714	1.000
30 − 40	0.070		0.055		0.025		0.286	
40 − 50	0.057	0.464	0.007					
50 − 60	0.087							
60 − 70	0.007							
70 − 80	0.000							
80 − 90	0.000							

The few metallic eruptions observed are confined to the southern hemisphere; the distribution of the faculæ is in accord with that of the spots, and the frequency is greater south of the equator for the faculæ, spots and eruptions.

The prominences, on the contrary, have been a little more frequent in the northern hemisphere, and they have also occurred in much higher latitudes, as compared with the other phenomena. The law which regulates the distribution of the prominences at the surface of the Sun is thus quite different in relation to the faculæ and spots, and it is consequently difficult to attribute the production of all of these phenomena to the same cause; it may even be called impossible.

The prominences are few near the equator and absent in the regions (± 70° ± 90°); we are thus still far from the *maximum* of chromospheric phenomena, although there are so many spots at the present time. Probably the maximum of aurorae will also be retarded if they are, as I have always thought, more closely related to the prominences than to the spots.

R. Osservatorio del Collegio Romano, Rome, 3 June, 1892.

* Communicated by the author.

ON A PROMINENCE OF EXTRAORDINARY HEIGHT OBSERVED MAY 5, 1892.*

JULIUS FENYI.

On May 5, a short time before 12^h (Kalocsa mean time), I observed a singularly bright and very high prominence at position angle 97° 24′ — 101° 30′, which at $10^h\ 25^m$ was not seen at that place; only a few faint and insignificant elevations were there at that time. The prominence which had risen during the interval consisted of very bright streamers, the lower part inclined about 70° with the equator; the upper part was more inclined, and was cloud-like in appearance, while the lower part was banded. About $11^h\ 55^m$ four transits over the slit gave a height of about 139″, without evidence of a rapid uprush. Unfortunately passing clouds prevented complete and uninterrupted observation of details. Beginning at $12^h\ 11^m$ rapid rising was observed; transits immediately following each other giving considerably increased heights. At $12^h\ 17^m\ 34^s$ it had reached 287″, and at $12^h\ 18^m\ 45^s$ it had risen to 317″; *i. e.*, with a velocity of 306 kilometers per second. The lower parts vanished during these few minutes, so that at $12^h\ 21^m\ 9^s$ nothing could be seen up to a height of 360″. The parts floating at this height rose with the enormous velocity of 368 kilometers to a height of 531″, which was measured at $12^h\ 29^m\ 25^s$. The highest fragment stood exactly over the position 90°; the time of transit was 37^s. The absolute height was 0.557 of the Sun's semi-diameter, corresponding to 381,800 kilometers, or 51,400 geographical miles.

Kalocsa mean time.			Height.	Velocity in kilometers per second.
h	m	s		
11	55	0	140	
12	17	34	287	306
12	18	45	317	
12	21	9	368	257
—	—	—	377	142
12	25	0	404	
—	—	—	410	368
—	—	—	480	
12	29	25	531	

It remains to be said that also in this case the highest parts showed the greatest proper motion in the line of sight. The highest streamers, in about the last quarter of the height, were

* Communicated by the author.

all displaced toward the blue. The amount of the displacement was measured by a single setting of the filar micrometer, and gave a velocity of 368 kilometers per second, exactly the same as that of the uprush mentioned above. Somewhat later a place at the limb, at about 101°, showed a marked motion toward the red. The heliographic latitude of the place of eruption was — 30° 43′ to — 34° 49′; longitude 142°.

If we combine the simultaneously observed motion of the uprush and the velocity in the line of sight to form a resultant, we obtain the enormous velocity of 520.4 kilometers per second. Since at the height of 531″ above the surface a body falling from an infinite distance can have attained a velocity of only 451 kilometers per second, it follows that the velocity of 520 kilometers per second in this prominence carried the matter entirely away from the Sun into space.

The eruption did not necessarily take place exactly on the limb, but possibly at a place on the visible disc or behind the limb. For the prominences observed at 9^h at the positions 127°, 106°, and 79° remained of the same form after the eruption; even a small bright flame at 90° remained entirely unchanged.

Observation of the solar surface revealed neither faculæ nor spots to which this enormous eruption could have been referred.

KALOCSA, Hungary, 22 May, 1892.

PHOTOGRAPHS OF THE OCCULTATION OF MARS BY THE MOON (JULY 11, 1892), MADE AT THE KENWOOD ASTROPHYSICAL OBSERVATORY.

GEORGE E. HALE.

Our new photographic objective by Brashear has now been in place on the equatorial for about a week, and among other objects we have been making a number of photographs of the Moon by its means. This objective, which is corrected for the Hγ line, has an aperture of 12 inches and a focal length of 18 feet. It is mounted in a double cell with a visual objective of the same aperture and focal length on the single tube of the equatorial. The projecting half of the cell support is braced to the tube by iron rods. At the eye-end of the tube a tail-piece is supported on the side by similar braces; so that we have the two objectives side by side, one with and the other without a tube. The double cell is similar to the double nose-piece of a microscope, and by loosen-

Mars emerging from occultation, July 11, 1892. Photographed at the Kenwood Astro-Physical Observatory, Chicago.

ing two clamping screws the cell may easily be rotated about an axis parallel to the tube, thus making the objectives readily interchangeable. This arrangement is a very convenient one, as the large spectroheliograph is permanently attached to the tube, and for different classes of work it is necessary to use both the visual and the photographic objective with it. No difficulty has been experienced in regard to the centering.

The accompanying photograph of Mars emerging from occultation was taken by Mr. G. W. Ritchey on July 11, 1892. The photographic objective was used without the tube, as the definition seems to be better than when the tube is employed. The exposure of ¼ second proved to be very satisfactory for both Mars and the Moon. In spite of the fact that the air was not very steady at the time the original negative is quite sharp, and although the image of Mars is only about $\frac{1}{32}$ inch in diameter, not only are the polar-caps very clearly shown, but also some other markngs on the surface. In the present photograph about one-third of the planet is hidden behind the dark limb of the Moon. Three other photographs were secured by Mr. Ritchey, showing the planet after egress. The half-tone cut is made directly from a six-fold enlargement of the original negative.

KENWOOD ASTRO-PHYSICAL OBSERVATORY,
Chicago, July 12, 1892.

A REMARKABLE SOLAR DISTURBANCE.

GEORGE E. HALE.

On July 15, 1892, there occurred on the Sun a phenomenon which in suddenness of appearance, exceptional brilliancy, and rapidity of change in form and brightness might almost be ranked with the classic observation of Carrington and Hodgson in 1859. The scene of the disturbance was the active spot in the southern hemisphere, whose high heliographic latitude and rapid changes in form have directed to it more than usual attention.

A photograph of the Sun, showing the faculæ, spots and prominences, was taken with the spectroheliograph of the Kenwood Observatory on July 15 at about $11^h\,8^m$ A. M. (Chicago Mean Time) and showed nothing unusual in the spot in question, except that the facula running between the northern and southern umbræ of the spot was brighter than usual. The next photograph, taken at about $11^h\,20^m$, showed a very different state of affairs. Extend-

ing between the umbræ, in a direction slightly inclined to the Sun's equator, was a perfectly straight and exceedingly brilliant object, which expanded slightly at its eastern extremity, and turned sharply toward the north, terminating abruptly in a brilliant ball just east of the center of the northern umbra. The sudden formation of this remarkable object did not seem to affect the general group of faculæ surrounding the spot, for they remained in practically the same form as at first. As the plates were not developed immediately we knew nothing of the disturbance, and the next photograph was not taken until about $11^h\ 47^m$. Meanwhile an entire transformation had taken place in the luminous phenomenon, and so completely were the umbræ covered by the brilliant outbursts that they were no longer visible in the photograph. The straight tongue running between the umbræ in the first photograph had developed into an S-shaped form, similar in appearance to a facula shown in our photographs of the great February Sun-spot when on the eastern limb. Brilliant forms had also appeared to the northwest of the northern umbra, and the disturbance extended over an area of about four billion square miles.

Unfortunately no more exposures were made until $1^h\ 21^m$, when eleven photographs of the spectrum of various parts of the spot region showed nothing out of the ordinary. A photograph of the Sun exposed at $1^h\ 41^m$, and another at $1^h\ 50^m$ show the forms of the great region of faculæ surrounding the spot to be the same as they were before the disturbance, which had now completely disappeared.

My visual observations were few, for until toward the end of the disturbance I did not know of its existence. About $0^h\ 45^m$, however, I observed the C line in the spectrum of the spot and found, at some distance to the west of the group, that the reversals were so brilliant that the forms could be very well seen with the slit quite widely opened. A sketch of these forms was made at this time by my assistant, Mr. G. Duwalt, who informs me that he happened to glance at the projected image of the spot during the time of disturbance, but noticed no unusual appearance.

The fact that the faculæ surrounding the spot were not materially changed in form by the disturbance seems to me to indicate that the phenomenon occurred in a region higher above the photosphere than that occupied by the faculæ: in other words, we seem to be dealing with an extremely brilliant eruptive prominence. Mr. Carrington came to a somewhat similar conclusion

in regard to the two brilliant objects seen by him, which were much inferior in size to the phenomena we are now considering, but probably much brighter. In the *Monthly Notices* for November, 1859, he says: "It was impossible, on first witnessing an appearance so similar to a sudden conflagration, not to expect a considerable result in the way of alteration of the details of the group in which it occurred; and I was certainly surprised, on referring to the sketch which I had carefully and satisfactorily (and I may add fortunately) finished before the occurrence, at finding myself unable to recognize any change whatever as having taken place. The impression left upon me is that the phenomenon took place at an elevation considerably above the general surface of the Sun, and, accordingly, altogether above and over the great group in which it was seen projected." Mr. Carrington goes on to add: "Both in figure and position the patches of light seemed entirely independent of the configuration of the great spot, and of its parts, whether nucleus or umbra." With this point my own observation does not fully agree, for the first outbreak occurred exactly on the line of separation of the two umbræ, where it would not be likely to be projected by chance alone. I am inclined to think that the luminous phenomenon had its origin in the spot region, and was eruptive in character.

I have as yet received no information in regard to the magnetic record at the time of disturbance.

KENWOOD ASTRO-PHYSICAL OBSERVATORY,
Chicago, July 16, 1892.

ASTRO-PHYSICAL NOTES.

All articles and correspondence relating to spectroscopy and other subjects properly included in ASTRO-PHYSICS, should be addressed to George E. Hale, Kenwood Astro-Physical Observatory, Chicago, U. S. A. Authors of papers are requested to refer to page 640 for information in regard to illustrations, reprint copies, etc.

The Spectra of Sun-Spots and the Chromosphere.—Everyone interested in solar work will be glad to learn that Professor C. A. Young has resumed his spectroscopic investigations on the Sun, with the large spectroscope described in the April number of this journal. The grating used with this instrument has 20,000 lines to the inch, and is characterized by Professor Young as "on the whole the best grating I have ever seen, and very near to ideal perfection." In a recent letter he adds: "I am going over my old observations of prominence and spot spectra, to fix the positions of the lines with accuracy, and review the identifications of elements present. The recent work of Rowland throws a flood of light on these spectra. One interesting result is the conspicuousness of *Vanadium* in

the spectrum of Sun-spots. Between C and D every one of the 28 lines of that metal found in that region of the spectrum is made conspicuous in the spot-spectrum, although almost evanescently faint in the photosphere. I have not yet had time to carry the comparison clear through the other regions of the spectrum. While I am about it I might note also that I have been able to fix accurately the wave-length of the first line in the Chromosphere Catalogue, by comparing it in the second and third order spectrum with the underlying spectra of the third and fourth order: it comes out 7065.5 ± 0.05, instead of 7055 ? as given in the old catalogue. It falls in a place where direct comparison was not possible with any wave-length map, and the identification on the prismatic maps was extremely difficult and uncertain because of the continually varying appearance of the atmospheric lines among which it is situated."

Professor Young has also secured a number of photographs of Sun-spot and chromosphere spectra, and two positives on glass of the chromosphere spectrum which we have recently received from him are beautifully sharp. One of these shows the hydrogen α_1 line (λ 3889) clearly double, and thus confirms the results on this point obtained at the Kenwood Observatory. The line is certainly not always double, but very frequently so. The double reversal of the H and K lines in spots, which was pointed out in a paper on "Spectroscopic Observations of the Great Sun-Spot of February, 1892," in the April number of ASTRONOMY AND ASTRO-PHYSICS, has also been confirmed by Professor Young's photographs.

Observation of a Solar Prominence.

TORONTO, Canada, June 13, 1892.

Professor George E. Hale.

Kenwood Astro-Physical Observatory, Chicago.

DEAR SIR:—I beg to direct your attention to a phenomenon observed by me, 1892, June 12, between 7^h 45^m and 8^h 20^m morning, standard time. I had just commenced examination of the solar limb in search of prominences, the instruments employed being a 4-in. equatorial refractor (Wray) and a diffraction spectroscope with Rowland grating. The slit was placed tangential to the limb at position angle 300 approximately, and the focus adjusted for the C line. When the slit was opened I at once noticed a glowing hydrogen cloud hanging suspended above the chromosphere and entirely detached from it. It was much brighter than such clouds usually appear and seemed to roll or move in a manner which made its outline indistinct notwithstanding its vividness. At the moment I attributed this to terrestrial atmospheric tremors (though I subsequently came to believe the motion real)—and made several alterations of focus to improve the seeing. In about five minutes the outlines became sharper and I was that a short conical body like the upper portion of an eruptive prominence was now visible below the cloud, but still detached from the limb. Concluding that the change of aspect was due to better seeing, I proceeded to sweep all round the Sun's limb in search of other forms, and after 10^m thus occupied, returned to the first position to re-observe the object I had before noticed; but could no longer recognize it in theform which I then discovered,—*i. e.* a tall shining pillar-like column very bright and sharply defined. About 5^m were occupied in carefully examining the limb all round the position where the floating cloud-mass had been seen, to assure myself that I had not missed it by an erroneous setting of the circle, but I was soon convinced that the bright pillar occupied the exact site of the other form. Continuing to observe this column, I found it rather rapidly becoming faint while at the same time it was declining or bending over. While its P. A.

was being ascertained with more exactness, it rapidly diminished in brightness and 5^m later had vanished entirely. I however noted that the chromosphere at that point and for some degrees on each side of it, was more brilliant and more sharply defined than elsewhere round the limb.

I now feel convinced that the fluctuations noted in the original cloud when first seen were due to actual motions of the mass in the line of sight, and not to atmospheric tremor; and that the change in appearance also really took place and was not, as I at the moment supposed, an improved view of the original form. I greatly regret that I did not continue to study the changes it was undergoing, as this would have revealed whether the cloud became actually metamorphosed into the pillar-like form. Of course it may be said that the former simply faded away while an eruptive prominence shot up from just below its site; but bearing in mind the size and density of the cloud, I cannot believe that this was what occurred. It seemed to be taking on a pillar-like form while I viewed it, an idea which passed through my mind at the moment, but unfortunately did not deter me from prosecuting the preliminary sweep for other forms so that no measurements or spectroscopic study with a narrow slit were made.

I should much like to know whether any of these phenomena were seen or photographed at your Observatory on the occasion in question. During the ten years in which I have made spectroscopic examination of the chromosphere forms a special study (so far as my rather limited leisure will allow) I have seen many gaseous or metallic uprushes gradually spread out into cloudy forms, but never the converse. However, in this instance, I almost believe that by a whirling action the cloud was gathered together and drawn down to the solar surface.

I trust you will pardon this lengthy communication which I am encouraged to send in view of your having expressed to the Astronomical and Physical Society of Toronto a desire to hear of spectroscopic observations made by the members. Respectfully yours, A. F. MILLER.

Sun-Spots and Magnetic Storms.

SALT LAKE CITY, Utah, July 13th, 1892.

Professor George E. Hale, Chicago, Ill.

DEAR SIR:—The two tables of dates of large Sun-spots and magnetic storms as published in June ASTRONOMY AND ASTRO-PHYSICS confirms, it seems to me, the theory advanced by the late Professor Tice. of St. Louis, in support of his Electro-magnetic Planetary Theory of Meteorology, namely, that the Sun and planets are electrically and magnetically disturbed when the one passes through the equatorial plane of the other and also when the one makes its nearest approach to the poles of the other, which of course would be 90° from the nodes on the plane.

Some months ago, Professor C. A. Young had the kindness to furnish me with a table of the heliocentric position of the nodes of the various planets on the solar equator. These values he says are based on Carrington's estimate of the Sun's inclination to the ecliptic and are as follows: Mercury, 145° 13′; Venus, 71° 52′; Earth, 73° 28′; Mars, 79° 18′; Jupiter, 68° 12′; Saturn, 53° 03′; Uranus, 73° 30′; Neptune, 60° 11′.

By comparing the dates as given in the above mentioned tables with the heliocentric position of the planets (especially of Mercury and Venus) on those dates, I find that in a majority of cases the planets were either directly at, or, at least, very near their solar nodes, or at their greatest declination from the

plane of its equator. I herewith enclose a table of dates combined from the two tables above mentioned with the approximate position of the planets on or about those dates, and you can see for yourself whether there is a relation between the two events or not. There is no doubt in my mind, but that there is a relation, and that the passage of a planet through its solar nodes is the direct cause of many solar disturbances and all its accompanying phenomena.

I would like to investigate the matter further but I have not the necessary data, and would suggest that Mr. Maunder or others that may have access to the magnetic records and other data would investigate further by comparing the position of the planets in respect to the solar equator and poles and solar disturbances, and I firmly believe that the mooted relation would be shown to exist. Yours truly, F. H. HESSE.

1880	Aug. 12.	♀ 162° on 13th. ☿ 325° on 16th.
1881.	Jan. 31.	♀ 72° on 29th. ☿ 325° on 31st.
"	Sept. 12.	♀ 72° on 12th.
1882.	Apr. 16.	☿ 325°.
"	" 20.	☿ 325° on 16th. ♀ 72° on 24th.
"	Oct. 2.	
"	" 5.	♀ 342° on 9th.
"	Nov. 17.|	Saturn 53° 03 on 25th.
"	" 21.|	
1883.	Apr. 3.	☿ 325°.
"	" 19.	☿ 55° on 21st.
"	June 30.	☿ 325°
"	July 11.	♀ 72° on 17th.
"	" 29.	☿ 145° on Aug. 2d.
"	Sept. 17.	
"	Oct. 16.	☿ 55° on 14th. ♂ 79° on 11th.
"	" 20.	
"	Nov. 1.	☿ 145° Oct. 29th. ♀ 252° on 6th.
"	" 19.	☿ 235° on 23d.
1884.	Mar. 2.	⊕ 343° on 3d. ♀ 72° on Feb 27th.
"	Apr. 24.	☿ 145° on 22d. ♀ 162° on 22d. ♂ 169° on 25th.
"	" 30.	♂ 169° on 25th.
"	July 2.	☿ 55° on 4th.
"	Oct. 1.	☿ 55° on Sept. 29th.
"	Nov. 2.	♂ 259° on Oct. 28th.
1885.	Jan. 23.	♀ 252° on 28th.
"	Feb. 5.	☿ 235°.
"	" 13.	
"	Mar. 15.	
"	May 26.	♀ 72° on 21st. ☌ 158°.12 on 25th.
"	June 24.	☿ 55° on 20th.
"	July 18.	♀ 162° on 16th.
1886.	Mar. 30.	☿ 145° on 27th.
1891.	Nov. 22.	
1892.	Feb. 13.	

As the true inclination of the Sun is not exactly known, the given value of the nodes may be several degrees in error. F. H. H.

Mr. S. W. Burnham returns to Chicago.—Chicago astronomers are delighted to welcome Mr. Burnham back to his old home after his absence of some years at the Lick Observatory. Though in becoming clerk of the U. S. Circuit court in this city, Mr. Burnham retires from professional work in astronomy, we trust that his observing days are by no means over, and that he will add many another difficult pair to his long list of double-star discoveries.

Dr. Henry Crew's Election as Professor of Physics in Northwestern University.—It is with no less pleasure that we learn from Dr. Henry Crew, recently Mr. Burnham's colleague at the Lick Observatory, that he has accepted the position of Professor of Physics in Northwestern University. Astronomical and spectroscopic work in Chicago will receive fresh impetus from the accession of two such well-known investigators as Mr. Burnham and Professor Crew.

Magnetic Disturbances and Auroras.—We have received from the U. S. Naval Observatory copies of the records of the more important magnetic perturbations during the first half of 1892. These occurred on Jan. 5, 29; Feb. 2, 3, 13; March 1, 2, 3, 4, 5, 6, 12; April 26; May 1, 18. A comparison with the solar photographs obtained at the Kenwood Observatory brings out several points of interest, which will be published in the near future.

On July 13 and 16 auroras were observed at the Kenwood Observatory, in connection with the magnetic storm which the telegraph companies report as more or less troublesome during nearly the whole of the preceding week. The aurora of July 16 was in every respect a remarkable one. About $9^h\ 35^m$ P. M. (Chicago Mean Time) a broad arc, pale green in color, was seen extending from N. E. to N. W. about 15° above the horizon at its highest point. Soon long shafts of light shot upward from the arch, and these coalescing, filled the entire northern sky with a brilliant dome of light which terminated abruptly about 15° south of the zenith. The arch had now disappeared, and about $9^h\ 55^m$ the whole northern sky was aflame with brilliant streamers, which flashed and pulsated continually. The flashes were such that small luminous masses seemed to be thrown through the air, from north to south. This was at first most brilliant in the N. E., but soon grew fainter there, and became more noticeable in the N. W. At about $10^h\ 13^m$ the long greenish arch appeared again, with straight streamers rising from it, which moved slowly toward the west. A pink tinge now spread over the whole northern sky. At $10^h\ 17^m$ the arch and pink color were much fainter, and at $10^h\ 22^m$ the aurora had almost completely disappeared.

There seems to be every reason to attribute these magnetic perturbations and auroral displays to the Sun-spot in remarkably high southern latitude which is now nearing the western limb. But though the spot has shown exceptional activity during the entire time of its transit across the disc, it is strange that the remarkable phenomenon in the spot photographed at the Kenwood Observatory on July 15, and described on another page, should not have been accompanied by some violent magnetic disturbance. In answer to a telegraphic inquiry addressed to the U. S. Naval Observatory on July 15, I have received the following answer, dated July 16: "Disturbance on twelfth and thirteenth; one in progress now; none on fifteenth *at eleven*; will send prints of record by mail. S. J. Brown, in charge Magnetic Observatory." The prints have not been received as we go to press.

Lewis Morris Rutherfurd.—The death of Mr. Rutherfurd, which occurred on May 30, 1892, will be deeply regretted by all who know of his important part in the advancement of science. A pioneer in astro-physical investigation, Mr. Rutherfurd's success in the study of stellar and solar spectra, in solar, lunar and stellar photography, and in the manufacture and use of the beautiful diffraction gratings which he distributed with so liberal a hand, has given him an honorable and a lasting place in the history of astronomy. When it is remembered that his photographs of spectra and of celestial objects are hardly surpassed to-day, after

the remarkable improvements in photographic processes which have been brought about during the intervening years, we may in some degree appreciate what it meant to obtain such results in the days when the spectroscope was a new instrument and photography an almost unknown art. In the next number of ASTRONOMY AND ASTRO-PHYSICS we hope to give an article on Mr. Rutherfurd's life and work.

Since the note on the Ultra-Violet Spectrum of Solar Prominences (page 602) was written I have succeeded in photographing the following bright lines in metalic prominences and in the chromosphere, the color correction of the new objective assisting very materially in the more refrangible part of the spectrum. As in the preceding table, lines not previously known are marked with an asterisk:

Lines.	*Elements.*
*3737.2	
3721.9	Hydrogen (η_1)
*3720.0	
3711.8	Hydrogen (δ_1)
*3704.0	" (ι_1)
*3697.4	" (κ_1)
*3691.5	" (λ_1)
*3686.7	" (μ_1)
3685.3	

The lines 3704.0, 3697.4, 3691.5 and 3686.7 are considered to belong to the hydrogen series, as they agree closely with the values calculated from Balmer's law. New lines are suspected at 3820.6 and 3745.6 Most of the above wavelengths are to be regarded as approximate only.

The two tables taken together constitute a complete catalogue of the ultraviolet prominence spectrum so far as known. The hydrogen series may be further extended, and many more metallic lines added, as the maximum period of solar activity is approached.

July 26, 1892.

Errata.—p. 64, column 5 in table; for "Ascent per sec. of time," read "Ascent per 30 sec. of time."

p. 433, last part of table should read:

5197	Line itself not seen. Prominence only.
5188.2	
b_1, b_2, b_3, b_4	Exceedingly bright.
5019.3	Ti; in this line the prominence is about 3 times as bright as in the next.
5016.6	Ni.
4945.5	Fe?
$10^h\ 38^m$ 4923.1	Fe: 40″: D; about 3 times as bright in this line as in the next.
4921.	

Visibility of Venus.—Mr. A. Cameron, of Yarmouth, Nova Scotia, writes that he was able to see Venus with the naked eye *easy* at $12^h\ 30^m$ P. M., July 6, three days before conjunction. The planet was only 6.5° distant from the Sun. In a pamphlet recently published Mr. Cameron discusses the question of the visibility of Venus and finds that it is possible to get glimpses of the planet without instrumental aid on at least 552 out of the 584 days of her synodical period.

Mr. F. P. Leavenworth has resigned his position as director of Haverford College Observatory to accept that of Professor of Astronomy in the University of Minnesota.

CURRENT CELESTIAL PHENOMENA.

PLANET NOTES FOR AUGUST AND SEPTEMBER.

H. C. WILSON.

Mercury will be "morning star" during September, reaching greatest western elongation Sept. 11. It will be visible to the naked eye for a few mornings about that time. To see it one should look toward the east, a little above the horizon, about an hour before sunrise. In October the planet will be invisible with small telescopes, passing superior conjunction Oct. 7.

Venus will also be "morning star" during these months, blazing with a brilliancy equal to that which she had in the evening sky during April and May. She passes greatest elongation west of the Sun Sept. 18. After that time she will move slowly toward the Sun but will be visible in the morning for several months. Venus will be in conjunction with the Moon, 7° 36′ south, Sept. 16, at $3^h\ 56^m$ P. M., Central time, and again, 4° 27′ south of the Moon Oct. 16 at 9 A. M.

Mars will begin to rise rapidly in declination in September and so come into better position for observation in northern latitudes, although receding from the earth so that his apparent diameter will be less. He will be stationary in right ascension, at the west end of the loop in his path in Capricornus (see May number, p. 439). Mars is a brilliant object in the heavens nowadays, rivalling Jupiter and Venus in splendor. We had an excellent view of this planet, through Professor Hale's 12-inch refractor at Kenwood Physical Observatory, on the morning of July 6. The southern polar cap was very large and sharply defined, the outline of the nearer side appearing as a perfect ellipse. There was another white area just south of it, near the east limb of the planet. One of the great continents was on the meridian and the seas bounding it on the south and west were very distinct, their dark greenish blue color contrasting strongly with the brick red of the land. Although dark shadings were seen on the red areas no fine lines corresponding to the "canals" were seen. We had, however, only a few minutes to spend in this examination, and longer looking might have brought out much more of detail.

There will be an occultation of Mars by the Moon on Sept. 4, visible throughout the United States beginning, as seen from Washington, at $1^h\ 30^m$ A. M eastern time, $12^h\ 30^m$ central time, and ending at $2^h\ 14^m$ A. M., eastern time, $1^h\ 14^m$ central time.

On the morning of October 25, at $4^h\ 41^m$ central time, Mars will approach very near to the third magnitude star δ Capricorni. In some localities an occultation of the star by the planet may be seen.

Jupiter comes to opposition Oct. 12, and so during these months will be in excellent position for observation. For chart of his path through the constellations see June number, p. 530. As Jupiter this year is from 5° to 8° north of the equator he is much better situated for observation than during last year.

Jupiter will be in conjunction with the Moon Sept. 9 at 7 A. M. There will be an occultation of the planet seen from the equatorial regions of the Pacific Ocean and the southwestern part of the United States. There will be another occultation of Jupiter, Oct. 6, visible in Asia.

Saturn is too nearly in line with the Sun for observation during the months of September and October. He will be at conjunction on Sept. 25.

Uranus will also be too near the Sun. He comes to conjunction Oct. 29.

Neptune will be at quadrature, 90° east from the Sun, Sept. 3, and may be observed after midnight. He is in Taurus about 5° northeast of Aldebaran.

MERCURY.

Date. 1892.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Sept. 5	9 58.9	+ 11 04	4 10 A. M.	10 58.0 A. M.	5 46 P. M.
15.....	10 34.0	+ 10 20	4 07 "	10 53.7 "	5 38 "
25.....	11 37.5	+ 4 28	5 57 "	11 17.6 "	5 39 "
Oct. 5.....	12 42.8	− 3 08	5 52 "	11 43.3 "	5 34 "
15.....	13 44.7	− 10 32	6 44 "	12 05.7 P. M.	5 27 "
25.....	14 45.0	− 16 51	7 32 "	12 26.5 "	5 21 "

VENUS.

Sept. 5.....	7 58.2	+ 17 13	1 43 A. M.	8 57.4 A. M.	4 12 P. M.
15.....	8 35.9	+ 16 14	1 46 "	8 55.8 "	4 06 "
25.....	9 16.4	+ 14 28	1 55 "	8 56.8 "	3 59 "
Oct. 5.....	9 58.5	+ 11 56	2 08 "	8 59.5 "	3 51 "
15.....	10 41.3	+ 8 43	2 25 "	9 02.9 "	3 41 "
25.....	11 24.5	+ 4 57	2 44 "	9 06.7 "	3 30 "

MARS.

Sept. 5.....	20 44.4	− 23 58	5 21 P. M.	9 41.5 P. M.	2 02 A. M.
15.....	20 47.8	− 23 05	4 40 "	9 05.6 "	1 31 "
25.....	20 56.0	− 21 50	4 03 "	8 34.6 "	1 06 "
Oct. 5.....	21 08.6	− 20 17	3 29 "	8 07.7 "	12 46 "
15.....	21 24.2	− 18 30	2 57 "	7 44.0 "	12 31 "
25.....	21 42.3	− 16 29	2 27 "	7 22.7 "	12 19 "

JUPITER.

Sept. 5.....	1 31.4	+ 7 53	7 53 P. M.	2 27.7 A. M.	9 02 A. M.
15.....	1 28.1	+ 7 32	7 12 "	1 45.2 "	8 18 "
25.....	1 23.9	+ 7 06	6 30 "	1 01.7 "	7 33 "
Oct. 5.....	1 19.2	+ 6 37	5 48 "	12 17.6 "	6 47 "
15.....	1 14.1	+ 6 07	5 06 "	11 33.3 P. M.	6 01 "
25.....	1 09.3	+ 5 38	4 24 "	10 49.1 "	5 15 "

SATURN.

Sept. 5.....	12 06.4	+ 1 38	6 55 A. M.	1 05.0 P. M.	7 15 P. M.
15.....	12 10.8	+ 1 09	6 22 "	12 30.0 "	6 38 "
25.....	12 15.3	+ 0 42	5 50 "	11 56.1 A. M.	6 02 "
Oct. 5.....	12 19.9	+ 0 10	5 17 "	11 21 2 "	5 25 "
15.....	12 24.3	− 0 18	4 44 "	10 46 4 "	4 49 "
25.....	12 28.7	− 0 45	4 11 "	10 11.4 "	4 12 "

URANUS.

Sept. 5.....	14 05.2	− 12 13	9 49 A. M.	3 03 8 P. M.	8 18 P. M.
15.....	14 07.0	− 12 23	9 12 "	2 25.9 "	7 40 "
25.....	14 09.1	− 12 34	8 36 "	1 49.1 "	7 02 "
Oct. 5.....	14 11.3	− 12 46	8 00 "	1 11.6 "	6 24 "
15.....	14 13.7	− 12 58	7 24 "	12 35.0 "	5 46 "
25.....	14 16.2	− 13 11	6 44 "	11 54.1 A. M.	5 04 "

NEPTUNE.

Sept. 5.....	4 39.9	+ 20 36	10 05 P. M.	5 35.7 A. M.	1 06 P. M.
15.....	4 40.0	+ 20 36	9 26 "	4 56.5 "	12 27 "
25.....	4 39.8	+ 20 35	8 47 "	4 17.0 "	11 47 A. M.
Oct. 5.....	4 39.4	+ 20 34	8 07 "	3 37.3 "	11 08 "
15.....	4 38.8	+ 20 32	7 27 "	2 57.3 "	10 27 "
25.....	4 37.9	+ 20 30	6 47 "	2 17.2 "	9 47 "

THE SUN.

Sept. 5.....	10 59.4	+ 6 28	5 28 A. M.	11 58.3 A. M.	6 28 P. M.
15.....	11 35.3	+ 2 40	5 40 "	11 54.8 "	6 10 "
25.....	12 11.2	− 1 13	5 52 "	11 51.4 "	5 51 "
Oct. 5.....	12 47.4	− 5 06	6 04 "	11 48.2 "	5 32 "
15	13 24.3	− 8 53	6 16 "	11 45.6 "	5 15 "
25.....	14 02.2	− 12 26	6 30 "	11 44.1 "	4 59 "

Jupiter's Satellites.

Sept. 1	12	47	A. M.	I	Oc. Re.
	6	53	P. M.	I	Sh. In.
	7	52	"	I	Tr. In.
	9	07	"	I	Sh. Eg.
	10	04	"	I	Tr. Eg.
2	7	14	"	I	Oc. Re.
	11	40	"	III	Sh. In.
3	2	07	A. M.	III	Sh. Eg.
	3	49	"	III	Tr. In.
5	3	08	"	II	Sh. In
6	7	07	P. M.	III	Oc. Re.
	10	07	"	II	Ec. Dis.
7	2	16	A. M.	II	Oc. Re.
	2	18	"	I	Sh. In.
	3	11	"	I	Tr. In.
	4	32	"	I	Sh. Eg.
	11	31	P. M.	I	Ec. Dis.
8	2	33	A. M.	I	Oc. Re.
	7	01	P. M.	II	Sh. Eg.
	8	36	"	II	Tr. Eg.
	8	47	"	I	Sh. In.
	9	38	"	I	Tr. In.
	11	01	"	I	Sh. Eg.
	11	50	"	I	Tr. Eg.
9	8	59	"	I	Oc. Re.
10	3	42	A. M.	III	Sh. In.
13	7	50	P. M.	III	Ec. Re.
	8	47	"	III	Oc. Dis.
	10	31	"	III	Oc. Re.
14	12	42	A. M.	II	Ec. Dis.
	4	12	"	I	Sh. In
	4	33	"	II	Oc. Re.
15	1	26	"	I	Ec. Dis.
	4	18	"	I	Oc. Re.
	7	05	P. M.	II	Sh. In.
	8	30	"	II	Tr. In.
	9	38	"	II	Sh. Eg.
	10	41	"	I	Sh. In.
	10	55	"	II	Tr. Eg.
	11	23	"	I	Tr. In.
16	12	55	A. M.	I	Sh. Eg.
	2	35	"	I	Tr. Eg.
	7	55	P. M.	I	Ec. Dis.
	10	44	"	I	Oc. Re.
17	7	24	"	I	Sh. Eg.
	8	01	"	I	Tr. Eg.
20	9	40	"	III	Ec. Dis.
	11	50	"	III	Ec. Re.
21	12	08	A. M.	III	Oc. Dis.
	1	52	"	III	Oc. Re.
	3	17	"	II	Ec. Dis.
22	3	21	"	I	Ec. Dis.
	9	43	P. M.	II	Sh. In.
	10	47	"	II	Tr. In.
23	12	17	A. M.	II	Sh. Eg.
	12	35	"	I	Sh. In.
	1	07	"	I	Tr. In.
	1	12	"	II	Tr. Eg.
	2	48	"	I	Sh. Eg.
	3	18	"	I	Tr. Eg.
	9	49	P. M.	I	Ec. Dis.
24	12	29	A. M.	I	Oc. Re.
	7	04	P. M.	I	Sh. In.
Sep. 24	7	33	P. M.	I	Tr. In.
	7	55	"	II	Oc. Re.
	9	17	"	I	Sh. Eg.
	9	45	"	I	Tr. Eg.
25	6	55	"	I	Oc. Re.
28	1	42	A. M.	III	Ec. Dis.
30	12	21	"	II	Sh. In.
	1	03	"	II	Tr. In.
	2	30	"	I	Sh. In.
	2	51	"	I	Tr. In.
	2	54	"	II	Sh. Eg.
	3	28	"	II	Tr. Eg.
	11	44	P. M.	I	Ec. Dis.
Oct. 1	2	13	A. M.	I	Oc. Re.
	6	07	P. M.	III	Sh. Eg.
	6	59	"	III	Tr. Eg.
	7	10	"	II	Ec. Dis.
	8	58	"	I	Sh. In.
	9	17	"	I	Tr. In.
	10	09	"	II	Oc. Re.
	11	11	"	I	Sh. Eg.
	11	29	"	I	Tr. Eg.
2	6	13	"	I	Ec. Dis.
	8	39	"	I	Oc. Re.
3	5	40	"	I	Sh Eg.
	5	55	"	I	Tr. Eg.
7	2	59	A. M.	II	Sh. In.
	3	19	"	II	Tr. In.
	4	24	"	I	Sh. In.
	4	34	"	I	Tr. In.
8	1	39	"	I	Ec. Dis.
	3	57	"	I	Oc. Re.
	7	47	P. M.	III	Sh. In.
	8	27	"	III	Tr. In.
	9	45	"	II	Ec. Dis.
	10	07	"	III	Sh Eg.
	10	15	"	III	Tr. Eg.
	10	53	"	I	Sh. In.
	10	59	"	I	Tr. In.
9	12	22	A. M.	II	Oc. Re.
	1	06	"	I	Sh. Eg.
	1	11	"	I	Tr. Eg.
	8	08	P. M.	I	Ec. Dis.
	10	23	"	I	Oc. Re.
10	5	21	"	I	Sh. In.
	5	25	"	I	Tr. In.
	6	51	"	II	Sh. Eg.
	6	53	"	II	Tr. Eg.
	7	34	"	I	Sh. Eg.
	7	37	"	I	Tr. Eg.
15	3	29	A. M.	I	Oc. Dis.
	11	41	P. M.	III	Tr. In.
	11	50	"	III	Sh. In.
16	12	09	A. M.	II	Oc. Dis.
	12	42	"	I	Tr. In.
	12	47	"	I	Sh. In.
	1	33	"	III	Tr. Eg.
	2	08	"	III	Sh. Eg.
	2	46	"	II	Ec. Re.
	2	54	"	I	Tr. Eg.
	3	00	"	I	Sh. Eg.
	9	55	P. M.	I	Oc. Dis.
17	12	13	A. M.	I	Ec. Re.

Oct. 17	6	42	P. M.	II	Tr. In.	Oct. 24	9	10	P. M.	I	Sh. In.
	6	56	"	II	Sh. In.		9	35	"	II	Sh. In.
	7	08	"	I	Tr. In.		11	02	"	I	Tr. Eg.
	7	16	"	I	Sh. In.		11	23	"	I	Sh. Eg.
	9	09	"	II	Tr. Eg.		11	26	"	II	Tr. Eg.
	9	20	"	I	Tr. Eg.	25	12	07	A. M.	II	Sh. Eg.
	9	28	"	II	Sh. Eg.		6	07	P. M.	I	Oc. Dis.
	9	29	"	I	Sh. Eg.		8	37	"	I	Ec. Re.
18	6	41	"	I	Ec. Re.	26	5	29	"	I	Tr. Eg.
23	2	21	A. M.	II	Oc. Dis.		5	52	"	I	Sh. Eg.
	2	25	"	I	Tr. In.		6	38	"	II	Ec. Re.
	2	42	"	I	Sh. In.		7	55	"	III	Ec. Re.
	2	54	"	III	Tr. In.	31	1	23	A. M.	I	Oc. Dis.
	3	52	"	III	Sh. In.		4	03	"	I	Ec. Re.
	11	39	P. M.	I	Oc. Dis.		10	35	P. M.	I	Tr. In.
24	2	08	A. M.	I	Ec. Re.		11	05	"	I	Sh. In.
	8	51	P. M.	I	Tr. In.		11	16	"	II	Tr. In.
24	8	58	"	II	Tr. In.						

Approximate Central Times when the Great Red Spot will pass the Center of Jupiter's Disk.

Aug.	5	7	29 P. M.	Aug.	29	7	15 P. M.	Sept.	24	12	46 A. M.
	6	5	24 A. M.		31	1	02 A. M.		24	8	38 P. M.
	7	1	16 A. M.		31	8	53 P. M.		26	2	24 A. M.
	7	9	07 P. M.	Sept.	2	2	40 A. M.		26	10	16 P. M.
	9	2	54 A. M.		2	10	31 P. M.		28	4	02 A. M.
	9	10	45 P. M.		4	4	18 A. M.		28	11	53 P. M.
	11	4	32 A. M.		5	12	09 A. M.		29	7	44 P. M.
	12	12	23 A. M.		5	8	00 P. M.	Oct.	1	1	31 A. M.
	12	8	14 P. M.		7	1	47 A. M.		1	9	22 P. M.
	14	2	02 A. M.		7	9	38 P. M.		3	3	09 A. M.
	14	9	53 P. M.		9	3	25 A. M.		3	11	00 P. M.
	16	3	39 A. M.		6	11	16 P. M.		4	6	52 P. M.
	16	11	31 P. M.		10	7	08 P. M.		6	12	38 A. M.
	17	7	22 P. M.		12	12	54 A. M.		6	8	29 P. M.
	19	1	09 A. M.		12	8	46 P. M.		8	2	16 A. M.
	19	9	00 P. M.		14	2	32 A. M.		8	10	07 P. M.
	21	2	47 A. M.		14	10	24 P. M.		9	5	58 P. M.
	21	10	38 P. M.		16	4	10 A. M.		10	3	54 A. M.
	23	4	25 A. M.		17	12	01 A. M.		10	11	45 P. M.
	24	12	16 A. M.		17	7	53 P. M.		12	7	36 P. M.
	24	8	08 P. M.		19	1	39 A. M.		13	1	23 A. M.
	26	1	55 A. M.		19	9	31 P. M.		13	9	14 P. M.
	26	9	46 P. M.		21	3	17 A. M.		15	3	01 A. M.
	28	3	33 A. M.		21	11	08 P. M.		15	10	52 P. M.
	28	11	24 P. M.		22	7	00 P. M.				

Occultations Visible at Washington.

Date 1892.	Star's Name.	Magnitude.	IMMERSION Washington M. T. h	m	Angle f'm N pt. °	EMERSION Washington M. T. h	m	Angle f'm N pt °	Duration. h	m
Sept. 3	Mars		13	22	110	14	06	200	0	44
4	B.A.C. 7550	6	11	03	23	12	06	275	1	03
8	96 Piscium	7	17	14	91	18	10	208	0	56
11	A^1 Tauri	4	9	24	55	10	12	262	0	48
11	A^2 Tauri	6	9	33	79	10	23	237	0	50
26	22 Scorpii	5½	5	09	48	5	58	344	0	49
Oct. 6	*o* Piscium	4	8	36	352	9	02	301	0	26
7	*o* Arietis	6	9	06	105	9	48	191	0	42
8	32 Tauri	6	16	14	26	17	09	294	0	55
12	ω^1 Cancri	6	12	37	104	13	37	259	1	00

Configuration of Jupiter's Satellites at 10:30 p. m. Central Time

Sept.		Sept.		Oct.	
1	2 1 ○ 3 4	22	2 ○ 4 1 3	12	4 1 ○ 3 2
2	2 ○ 3 1 4	23	2 4 ○ 3 ●	13	4 ○ 2 1 3
3	3 1 ○ 2 4	24	4 3 1 ○ 2	14	4 2 1 ○ 3
4	3 ○ 2 1 4	25	4 3 ○ 1 2	15	4 2 ○ 3 1
5	3 2 1 ○ 4	26	4 3 2 1 ○	16	3 4 ○ 2 ●
6	4 2 ○ 3 1	27	4 2 3 ○ 1	17	3 2 1 4 ○
7	4 1 ○ 2 3	28	4 1 ○ 2 3	18	2 3 ○ 1 4
8	2 4 2 ○ 3	29	4 ○ 2 1 3	19	1 ○ 3 2 4
9	4 2 ○ 1 3	30	2 4 1 ○ 3	20	○ 2 1 3 4
10	4 3 1 ○ 2	Oct.		21	2 1 ○ 3 4
11	4 3 ○ 2 1	1	2 3 ○ 4 ●	22	2 ○ 3 1 4
12	4 3 2 1 ○	2	3 ○ 1 2 4	23	3 ○ 1 2 4
13	4 2 1 ○ ●	3	3 2 1 ○ 4	24	2 2 3 ○ 4
14	1 ○ 2 3 ●	4	2 3 ○ 1 4	25	3 2 ○ 1 4
15	2 ○ 1 4 3	5	1 ○ 2 3 4	26	4 1 ○ 3 2
16	2 ○ 1 3 4	6	○ 2 1 3 4	27	4 ○ 1 2 3
17	3 1 ○ 2 4	7	2 1 ○ 3 4	28	4 2 1 ○ 3
18	3 ○ 1 2 4	8	2 ○ 1 4 ●	29	4 2 ○ 3 1
19	3 2 1 ○ 4	9	3 4 ○ 2 ●	30	4 3 1 ○ 2
20	2 3 ○ 1 4	10	3 4 2 1 ○	31	4 3 ○ 1 2
21	1 ○ 2 3 4	11	4 2 3 ○ 1		

Occultations of Stars by the Planets.

[From *Astr. Nach.*, No. 3073.]

	Date		Central Time of Conjunction. h m	Diff. of Decl. ″	Maximum Duration. m	Magnitude of Star.
			STARS NEAR VENUS.			
1892.	Sept.	3	12 14 P. M.	+ 73	14.7	9.4
		5	5 35 A. M.	− 9	13.8	9.5
		6	2 17 A. M.	+ 17	13.4	9.4
		6	7 02 P. M.	− 51	13.4	9.4
		9	4 32 A. M.	− 75	12.6	9.3
		9	4 51 "	+ 40	12.6	9.3
		11	6 34 P. M.	+ 38	11.5	8.6
		12	3 44 "	− 40	11.2	9.3
		14	7 00 A. M.	+ 53	10.8	9.0
		19	7 52 P. M.	− 2	10.0	9.2
		21	9 47 "	+ 58	9.7	7.5
		28	8 46 A. M.	+ 41	8.7	9.0
		30	12 12 A. M.	− 9	8.5	8.3
	Oct.	1	3 34 P. M.	− 12	8.2	9 4
		2	12 25 P. M.	+ 29	8.1	9.4
		6	6 19 A. M.	+ 13	7.7	9.3
		8	8 29 P. M.	+ 37	7.5	9.3
		9	7 25 P. M.	+ 57	7.4	9.3
		12	1 58 A. M.	− 30	7.2	4.1
		20	2 34 P. M.	− 69	6.6	9.4
		20	5 26 P. M.	+ 50	6.6	9.3
		20	8 41 P. M.	− 92	6.6	9.3
		27	5 37 A. M.	− 68	6.1	8.7
			STARS NEAR MARS.			
	Sept.	25	8 41 P. M.	+ 17	25.0	9.2
		29	12 31 A. M.	+ 31	22.5	8.5
	Oct.	1	midn.	+ 29	19.8	9.0
		13	9 35 P. M.	− 24	14.0	9.0
		18	1 23 A. M.	− 7	12.8	9.2
		23	9 28 P. M.	+ 23	11.2	9.3
		25	4 41 A. M.	+ 31	11.0	3
			STARS NEAR JUPITER.			
	Oct.	6	2 06	− 38	150	9.5

Minima of Variable Stars of the Algol Type.

U CEPHEI.

R. A.....0h 52m 32s
Decl.....+ 81° 17′
Period.....2d 11h 50m

Sept.	5	9 P. M.
	10	9 "
	15	9 "
	20	8 "
	25	8 "
	30	8 "
Oct.	5	7 "
	10	7 "
	15	7 "
	20	6 "
	25	6 "
	30	6 "

ALGOL.

R. A.....3h 01m 01s
Decl.....+ 40° 32′
Period.....2d 20h 49m

Sept.	13	3 A. M.
	15	midn.
	18	9 P. M.
	21	6 "
Oct.	3	5 A. M.
	6	2 "
	8	11 P. M.
	11	7 "
	26	4 A. M.
	28	midn.
	31	9 P. M.

λ TAURI.

R. A.....3h 54m 35s
Decl.....+ 12° 11′
Period.....3d 22h 52m

Sept.	6	2 A. M.
	10	1 "
	13	midn.
	17	11 P. M.
	21	10 "

λ TAURI CONT.

Sept.	25	8 P. M.
	29	7 "

R. CANIS MAJORIS.

R. A.....7h 14m 30s
Decl.....— 16°.11′
Period.....1d 03h 16m

Sept.	6	2 A. M.
	7	5 "
	13	midn.
	15	4 A. M.
	21	midn.
	23	3 A. M.
	29	10 P. M.
Oct.	1	2 A. M.
	2	5 "
	8	midn.
	10	3 A. M.
	16	11 P. M.
	18	2 A. M.
	19	6 "
	24	10 P. M.
	26	1 A. M.
	27	4 "

U CORONÆ.

R. A.....15h 13m 43s
Decl.....+ 32° 03′
Period.....3d 10h 51m

Sept.	14	11 P. M.
	21	9 "
	28	7 "
Oct.	22	11 "
	29	9 "

U OPHIUCHI.

R. A.....17h 10m 56s
Decl.....+ 1° 20′
Period.....0d 20h 8m

Sept.	2	10 P. M.
	3	6 "

U OPHIUCHI CONT.

Sept.	7	10 P. M.
	8	6 "
	12	11 "
	13	7 "
	17	midn.
	18	8 P. M.
	23	1 A. M.
	23	9 P. M.
	28	1 A. M.
	28	10 P. M.
	29	6 "
Oct.	3	11 "
	4	7 "
	8	11 "
	9	7 "
	13	midn.
	14	8 P. M.
	19	1 A. M.
	19	9 P. M.
	24	10 "
	25	6 "
	29	11 "
	30	7 "

Y CYGNI.

R. A.....20h 47m 40s
Decl.....+ 34° 15′
Period.....1d 11h 56m

Sept.	3	1 A. M.
	8	midn.
	14	"
	20	"
	26	"
Oct.	2	"
	8	"
	14	11 P. M.
	20	11 "
	26	11 "

Phases and Aspects of the Moon.

		d	h	m	
Full Moon	Sept.	6	3	08	P. M.
Perigee	"	8	5	00	"
Last Quarter	"	13	6	50	A. M.
New Moon	"	20	7	16	P. M.
Apogee	"	24	noon		
First Quarter	"	29	12	19	A. M.
Full Moon	Oct.	6	12	12	"
Perigee	"	6	10	30	P. M.
Last Quarter	"	12	3	38	"
New Moon	"	20	12	24	"
Apogee	"	21	9	36	"
First Quarter	"	28	3	26	"

Aurora, July 16.—Mr. W. H. Clute, of Bay City, Mich., reports a very brilliant aurora seen at that place July 16, from 9h to 10h 30m P. M. The display was very active, covering nearly the whole sky. This aurora was noted at Northfield as was also one July 14. Our photograph of the Sun taken July 18 (the first taken after the 16th) shows that two new groups of spots had formed near the center of the Sun's disk.

COMET NOTES.

Swift's comet is still quite conspicuous in the telescope, and will be visible in ordinary telescopes for some time to come. Winnecke's comet has passed the Sun and is coming out of the morning twilight. It is only visible in southern latitudes. No new comets have been discovered during the past four months, nor have the periodic comets Brooks, 1886 IV, and Tempel, 1867 II, been found. What are all you amateurs doing?

Elements of Comet 1892 I (Swift March 6).—The following elements were computed by Miss F. E. Harpham from three normal places, dated March 11.0, 29.0 and April 17.0, depending upon all the published observations received before June 1. The representation of the middle place is: $d\lambda \cos \beta = -6.6''$; $d\beta = +4.3''$:

$$\left.\begin{array}{rl} T &= \text{April } 6.62792 \text{ Greenwich mean time.} \\ \pi &= 265^\circ\ 24'\ 04.7'' \\ \omega &= 24\ 29\ 42.4 \\ \Omega &= 240\ 54\ 22.3 \\ i &= 38\ 41\ 47.4 \end{array}\right\} 1892.0$$

$$\log q = 0.011536 \qquad q = 1.02692$$

Ephemeris of Comet *a* 1892 (Swift).

From my last elements, as given in the June number of this periodical, I have computed the following Ephemeris:

Gr. M. T.		App. R. A.		App. Dec.		log r	log Δ	Br.
		h	m s	°	′			
1892 Aug.	1.5	1	3 38	+ 51	56	0.3196	0.2553	0.12
	2.5		3 30	52	2			
	3.5		3 20	52	8			
	4.5		3 7	52	14			
	5.5		2 51	52	19	0.3295	0.2570	0.11
	6.5		2 32	52	24			
	7.5		2 12	52	29			
	8.5		1 48	52	34			
	9.5		1 23	52	38	0.3391	0.2587	0.10
	10.5		0 53	52	42			
	11.5	1	0 22	52	46			
	12.5	0	59 48	52	49			
	13.5		59 12	52	52	0.3485	0.2602	0.10
	14.5		58 33	52	55			
	15.5		57 53	52	57			
	16.5		57 8	52	59			
	17.5		56 21	53	0	0.3577	0.2618	0.10
	18.5		55 32	53	1			
	19.5		54 41	53	1			
	20.5		53 46	53	2			
	21.5		52 54	53	2	0.3668	0.2635	0.09
	22.5		51 57	53	2			
	23.5		50 59	53	1			
	24.5		49 58	53	0			
	25.5		48 56	52	59	0.3755	0.2653	0.09
	26.5		47 51	52	57			
	27.5		46 45	52	55			
	28.5		45 37	52	52			
	29.5		44 28	52	49	0.3842	0.2674	0.08
	30.5		43 18	52	45			
	31.5	0	42 6	+ 52	41			

O. C. WENDELL.

Harvard College Observatory, July 11, 1892.

Ephemeris of Winnecke's Periodic Comet 1892.

[Continued from page 537.]

Berlin Midnight	App. R. A.	App. Decl.	log Δ	log r	Br.
	h m s	° ′ ″			
Aug. 16	3 16 34	− 27 35 01	9.5150	0.0533	
17	14 21	27 52 12	9.5230	0.0567	6.93
18	12 08	28 08 45	9.5309	0.0601	
19	09 56	28 24 42	9.5386	0.0635	
20	07 42	28 40 03	9.5461	0.0669	
21	05 29	28 54 50	9.5535	0.0703	5.65
22	03 15	29 09 03	9.5608	0.0737	
23	3 01 00	29 22 41	9.5680	0.0771	
24	2 58 45	29 35 46	9.5751	0.0804	
25	56 29	29 48 17	9.5821	0.0838	4.66
26	54 12	30 00 14	9.5890	0.0872	
27	51 54	30 11 37	9.5958	0.0905	
28	49 35	30 22 26	9.6025	0.0939	
29	47 15	30 32 41	9.6092	0.0972	3.87
30	44 54	30 42 21	9.6158	0.1006	
31	42 32	30 51 26	9.6223	0.1039	
Sept. 1	40 09	30 59 56	9.6288	0.1072	
2	37 46	31 07 50	9.6353	0.1105	3.22
3	35 21	31 15 09	9.6417	0.1138	
4	32 56	31 21 51	9.6481	0.1170	
5	30 30	31 27 56	9.6545	0.1203	
6	28 04	31 33 23	9.6608	0.1235	2.70
7	25 38	31 38 13	9.6671	0.1267	
8	23 11	31 42 26	9.6734	0.1299	
9	20 44	31 46 02	9.6797	0.1331	
10	18 17	31 48 59	9.6860	0.1363	2.27
11	15 49	31 51 20	9.6923	0.1394	
12	13 22	31 53 04	9.6986	0.1426	
13	10 55	31 54 11	9.7048	0.1457	
14	08 28	31 54 41	9.7111	0.1488	1.91
15	06 02	31 54 32	9.7174	0.1519	
16	03 36	31 53 45	9.7237	0.1549	
17	2 01 11	31 52 21	9.7300	0.1580	
18	1 58 48	31 50 18	9.7363	0.1610	1.60
19	56 25	31 47 39	9.7427	0.1640	
20	54 04	31 44 22	9.7490	0.1670	
21	51 43	31 40 29	9.7554	0.1700	
22	1 49 25	31 36 00	9.7618	0.1729	1.35

Denning's comet during August will increase a little in brightness and may be visible in the great telescopes. We have no ephemeris at hand extending beyond August 5, when the comet will be in R. A. $6^h\ 07^m$; Decl. $+ 31° 48'$.

Search Ephemeris for Comet Tempel. (1867 II).

(From Astr. Nachr. No. 3095).

	Perihelion April 3.5. App. R. A.	Decl.	Br.	Perihelion March 24. R. A.	Decl.
	h m s	° ′		h m s	° ′
Aug. 8	17 50 10	− 33 04.7	0.08	18 14 06	− 34 01
13	52 16	08.7			
18	55 07	10.8	0.07	18 14 04	− 34 01
23	58 38	11.4			
28	18 02 51	− 33 10.6	0.06		
	Perihelion April 13.5.				
Aug. 8	17 26 52	− 31 53			
18	17 33 44	− 32 08			

Partial Eclipse of the Sun Oct. 20.—This will be visible throughout nearly the whole of North America. The eclipse begins at 10:15 A. M. central time, in longitude 133° 22′ west from Greenwich, latitude 65° 25′ north, and ends at 2:57 P. M., in longitude 50° 52′ west, latitude 14° 02′ north. The greatest eclipse will occur a short distance off the S. E. coast of Greenland, where 0.906 of the Sun's diameter will be covered by the Moon. We will give the times of beginning and ending at Northfield in our next number.

Elements of the Asteroids of 1891.

No.	Ω °	i °	φ ° ′	a	Computer.
303	345 15	6 55	3 47	3.12	Millosevich
304	158 51	15 30	12 41	2.42	Berberich.
305	210 34	4 26	11 07	3.10	Berberich.
306	141 33	7 14	8 43	2.36	Berberich.
307	101 38	6 07	8 37	2.91	Knopf.
308	182 22	4 31	1 34	2.73	Berberich.
309	357 52	3 56	5 02	2.63	Berberich.
310	230 24	3 06	6 32	2.76	Berberich.
311	81 13	3 16	1 18	2.89	Berberich.
312	7 29	8 59	0 30	2.79	Masson.
313	176 42	11 29	10 17	2.38	Berberich.
314	171 06	12 25	10 42	3.12	Charlois.
315	161 07	2 25	9 40	2.24	Bohlin.
316	124 47	2 20	7 33	3.18	Gutesmann.
317	150 39	1 45	4 53	2.29	Charlois.
318	162 51	10 33	4 03	3.19	Berberich.
319	188 58	10 43	12 34	3.40	Berberich.
320	221 36	8 55	7 14	3.00	Berberich.
321	40 31	2 39	2 09	2.88	Berberich.
322	253 55	8 09	15 23	2.81	Esmoil.
323					
324	328 54	11 06	18 28	2.67	Berberich.

An Occultation as seen at the Underwood Observatory, Appleton, Wis., by L. W. Underwood.—While observing the moon on the evening of May 30, I detected a telescopic star near her dark limb. A few moments of observation made it certain that an occultation would soon take place. As the moon was crescent her dark limb was in advance, as she journeyed among the stars. This proved a very profitable circumstance on this occasion. I was able to so adjust the telescope as to exclude from the field the bright limb and still plainly see the dark limb and the star.

A careful study of the light from the star was made from the time it was detected until the occultation took place, but not the slightest change could be detected. It seemed to remain perfectly uniform until the moon's dark limb reached it ($8^h\ 28^m$ P. M. central time) when it simply went out instantly. This fact would seem to indicate that if the moon possesses any atmosphere whatever it must be very rare indeed, too much so to support life as we know it.

Appleton, Wis., June 6, 1892.

Occultation of Mars.—Below I give the times of the four contacts of the occultation of Mars by the moon last night. It was nearly clear here and the seeing was good. The markings on the planet were well seen, especially the south polar cap. Some of the dark markings near the equator I recognize as ones I have seen at nearly every opposition since 1877. There can be no doubt but that they are permanent. Following are the times of the contacts, 75th meridian time:

	h	m	s
1st...11	26	4.5	
2d....11	27	5.5	
3d....12	29	6.0	
4th...12	30	12.5	

FRANK E. SEAGRAVE.

Seagrave Observatory, Providence, R. I., July 11, 1892.

NEWS AND NOTES.

Our next issue will be for the month of October, and it will be mailed about the first day of that month.

The attention of foreign subscribers is called to the fact that Northfield, the place of publication of this journal, is now a money order office.

Professor Asaph Hall, Jr., has been appointed director of the Detroit Observatory, Ann Arbor, Michigan.

J. A. Brashear is again at his shops in Allegheny, after an extended trip in Europe. His health is improved as the result of his journey.

Mr. Burnham's Resignation.—I have severed my connection with the Lick Observatory and desire to state that hereafter my address will be "Government Building, Chicago." S. W. BURNHAM.

Professor W. J. Hussey, formerly acting director of the Detroit Observatory of the University of Michigan, has been appointed to the position of Assistant Professor of Astronomy and Instructor in Mathematics at the Leland Stanford Jr., University, Pa'o Alto, California.

Changes in the Staff at the Lick Observatory.—It has been known for some time, that important changes would be made in the Staff of Lick Observatory. This has been understood by some astronomers acquainted with the personnel at Mount Hamilton, and it has also been noticed in the leading papers of San Francisco during the last two months. Hints that all things were not moving smoothly appeared in the resignation of Professor Keeler in the spring of 1891. Later Mr. Burnham has resigned, and now it appears that Professor Henry Crew is to exchange his place for the professorship of Physics in the Northwestern University at Evanston, Ill.

It is true that Professor Keeler was invited back to the Allegheny Observatory to take its directorship in the stead of our distinguished Langley, an honor indeed that he might well covet, but it was the wonder of his wider circle of friends that he should choose to leave the finest equipment of astronomical instruments in the world for another at present very ordinary, if not positively inferior, for common lines of modern research. Astronomers, the world over, know that Professor Keeler is a leading authority in spectroscopy, and that he had designed and most successfully used one of the most effective instruments in this research now known to the science. It is also well known that he had gained in a short time, for a young man, an enviable reputation at home and abroad by skillful work and astonishing results in the new and difficult spectroscopic study of the nebulæ. So true is this, that his dicta, in regard to the character and meaning of nebular spectra have been received as high authority everywhere by the best talent in astro-physics. Now it seems very strange that Professor Keeler would easily give up all this bright prospect, and be content to wait a long time before it can be possible for him to take up his delightful work where he left it more than a year ago. We think astronomers generally will wonder why Professor Keeler should abandon such a position as he held at the Lick Observatory, and so deprive himself and astronomy of the benefits in spectroscopical research which he was peculiarly fitted to prosecute.

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The cause of Mr. Burnham's resignation is also unknown. We have no theory to advance about it, but we remember his connection with the Lick Observatory from the first with personal interest and personal pride. We need hardly say to the readers of this journal that Sherman Wesley Burnham in 1879 was chosen by those in authority, as expert observer to go to California and determine the particular mountain site, where, later, the Lick Observatory should be located; and that subsequently, it was his report and his judgment of the fitness of the site at Mount Hamilton that led to its adoption more than that of any other man so far as we know. In a special sense would Mr. Burnham feel an interest in the growth and maintenance of that grand Observatory, since it was his work of testing the site with his immortal six-inch telescope, and the discoveries of double-stars there made in the first scientific expedition to the mountain top that give the beginning of interest in Mount Hamilton as a suitable point for astronomical work. Since that time Mr. Burnham has been identified in many important ways with the growth and the success of this great Observatory. His double star work must be acknowledged as without an equal anywhere. His catalogues, his standing in the Royal Astronomical Society of England and in other scientific societies on the continent fully attest this. His practical knowledge of photography and his studious application of it to various fields of astronomical work have gained for him wide reputation as not only an artist but an authority in this branch of science. In view of all this, it is a wonder that Mr. Burnham should leave Lick Observatory, and accept the position of a clerk in one of the courts of Chicago. It is true that the new position pays higher salary than that of senior astronomer in the Lick Observatory, but we are not aware that Mr. Burnham ever complained of the smallness of salary in any position that he ever held, however small. He is not that kind of a man, his mind and his purpose are too large to be swayed by such motives. This could hardly be true anyway in regard to the positions at Mount Hamilton, for they are all reasonably well paid in view of all the circumstances.

But the thing most to be regretted in these late changes, is the fact that this great Observatory is rapidly losing its great men. As necessary as powerful instruments are to high success in modern research, it must never be forgotten that men are more than instruments. Whatever the position the *man* must rank his place and his instruments or he will degrade both. That Director Holden has done masterful work in building up the Lick Observatory so far is admitted on every hand. That was no small thing to do. It was well done; not perfectly, as he well knows, and himself says, but, still, it was well done. And one of the best things in his part of it was, that he had the foresight to select and the ability to secure, for his staff, some of the best men to be found in the United States. In this he was eminently wise. But, now, that these excellent men are rapidly leaving the Observatory, it is not evident that he is wise in permitting this, if it lies in his power to prevent it. In any phase of the matter it is a calamity to the Observatory and to astronomy. For first-rate men, like any others, can do better work the longer they remain in one position, other things being equal. New men can not master large and delicate instruments in a day. It requires many a day of pains-taking labor and waiting for the skillful astronomer to get from his fine instrument the very best that it can give. It may do for manager Frick, at the Homestead Mills to say that he can easily get others to take the places of his trained men to work his improved machinery and turn out just as good armor plate, as in the past, but his skilled workmen know better. Much more is this true in scientific work, and we believe no one knows it better than does Professor Holden, and it is not probable that any course will be taken in the future

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which shall not be for the best interest of the Lick Observatory and for Astronomy in general.

As we close this paragraph the news comes to us that Professor Henry Crew, of Lick Observatory, has been elected Professor of Physics in the Northwestern University at Evanston, Ill. We are also informed that he will probably accept the position. Mr. Barnard and Mr. Schaeberle are the remaining older members of the staff.

Re-building Dudley Observatory.—Miss Catherine Wolfe Bruce of New York City has recently given twenty-five thousand dollars to the Dudley Observatory for the increase of its permanent endowment. Miss Bruce will be remembered for her munificent gift of $50,000 to the Observatory of Harvard College for the construction of a large telescope of special form, as also for numerous others in aid of astronomical research. In her offer of $25,000 to the Dudley Observatory for increase of endowment, Miss Bruce attached the condition that sufficient funds should otherwise be secured to remove and re-establish the Observatory on a better site. These conditions have been fulfilled. From various sources the sum of $31,700 has been secured to defray the cost of re-building the Observatory on a new site and to furnish it with a new equatorial of twelve inches aperture, together with other improvements in its equipment. The cost of the telescope is provided for by Robert C. and Charles L. Pruyn, sons of the late Robert H. Pruyn, formerly president of the trustees of the Dudley Observatory, and is intended to be a memorial in his honor. It is to be of the most approved modern construction.

The cost of re-establishment of the Olcott Meridian Circle (8 inches aperture), constructed by Pistor and Martins of Berlin in 1858, together with a collimating meridian mark and other improvements, is provided for by the liberality of three sons of the late Thomas W. Olcott, formerly president of the Observatory Trustees and the donor of the original instrument. The donors are Hon. Frederick P. Olcott of New York City and Dudley and John Olcott of Albany.

The working plans for the new Observatory are in process of preparation, and it is expected that the work of re-building will be entered upon during August of the present year.

The old site is very unfavorable to astronomical observation, owing to its proximity to the four tracks of the New York Central railroad which group around the base of Observatory Hill at a distance of about 150 yards from the instruments, with a very heavy traffic. The instruments and observing arrangements of the Dudley Observatory are much in need of improvement, and the necessary additions and alterations in the apparatus and observing rooms would have cost so large a proportion of the cost of absolute reconstruction on a new site that this consideration was regarded as a very strong factor in the determination to make the change. The new site is about two miles southwest of the present location, and in the southwestern part of Albany, upon a plot of about six acres, and surrounded by property in possession of the city park commission.

Civil Administration at the Naval Observatory.—Bills have been introduced in both houses of Congress, at the winter session of 1891-2, providing for a civil administration of the Naval Observatory, but retaining that institution in the Navy Department. The House bill was reported upon adversely by the committee on Naval affairs to which it had been referred; though it is not known that there were any public hearings at which opinions adverse to the general principle of the measure were expressed by any who addressed the committee. Dur-

ing the April session of the National Academy of Sciences, a hearing upon the bill was had before the Senate committee on Naval affairs. The attitude of this Senate committee is supposed to be favorable to the principle that the Government Observatory should be placed under the direction of an able civilian astronomer.

Late in the session an attempt was made to place an amendment in the Naval appropriation bill, providing for the appointment by the Secretary of the Navy of a commission to report a plan for organization of the new Observatory, in time for consideration at the next session of Congress. This amendment was passed by the Senate, but with some thirty other amendments failed to receive the concurrence of the House committee.

As the matter stands the bill for re organization of the Naval Observatory is before each branch of the National Legislature, but rests under the cloud of an adverse report in the House. There is no legal reason why this measure or some substitute for it may not be pressed to a vote at the next session of Congress.

The principal contentions made in the adverse report of the House committee on Naval affairs by the advocates of continued control of the Observatory by line officers of the Navy appear to be: first—that the Observatory was founded solely by the efforts of Naval officers, and that for some years it has been efficiently managed by them (though not so well of late); and secondly—that astronomers (scientific men generally) are not fitted for the larger administrative duties connected with scientific work! It will be difficult to convince any man conversant with the history of scientific work and with the circumstances under which this decision was reached that there is any force in such arguments, or that they are the real ones which inspired the report.

It appears to be the opinion of many experienced public men in Washington that this agitation, which is only in its initial stage, must soon result in the control of the Observatory by a competent practical astronomer.

The Star Camera at the Sydney Observatory.—We have been favored by H. C. Russell, Government Astronomer, at Sydney, Australia, with a quarto volume in board covers bearing title, "The Star Camera." The frontispiece is a full page photogravure of the 13.1-inch photographic telescope showing a considerable portion of the observing room. Very full descriptions and illustrations of the instrument and its working parts are given in this useful publication. We notice with interest, that two combinations of lenses are used with the enlarging camera—one giving a magnifiying power equivalent to a focal length of 47 feet, and the second equal to a focal length of 180 feet. With the first, very sharp pictures of the Moon, five and five and one-half inches in diameter can be taken in three or four seconds; but it is found that the best result is obtained by reducing the aperture of the 13.1-inch lens to four inches, and increasing the time of exposure to 20 seconds. Very satisfactory pictures of Jupiter, half an inch in diameter have been obtained, in which the belts are shown, and the red spot is much more conspicuous than it is to the eye aided by the 11½-inch equatorial.

The construction of the enlarging lenses is unusual. In each, two lenses of equal foci are placed convex to convex, and they are separated five-eighths of the sum of the foci of the two lenses. The pictures are said to be sharp and the field very nearly flat.

Professor Hall's Double Star Observations 1880-1891 Made at the Naval Observatory, Washington, have been received. The measures were made with the 26-inch equatorial, during the last sixteen years. The stars observed are mostly known binaries.

Professor W. H. Pickering's Note on the Color of Mars.—The following note on the color of Mars was sent by Professor W. H. Pickering, Arequipa, Peru, hoping that the same would reach us in time to accompany his article which was leader in our June issue. It was intended for a note to accompany matter found on page 451.

NOTE.—Since the blue light reflected from the Earth's atmosphere, superposed upon the red light reaching us from Mars, combines to produce upon our eyes the effect of orange,—the color which Mars appears by daylight,—it seems likely that the atmosphere of Mars may tend to produce the same effect, causing the planet to appear less red than is really the case. This would explain why the limb of Mars always appears less red than the center, and would not involve the assumption of an atmosphere about the planet capable of absorbing the red rays. That is, the appearance of the planet's limb may be due to reflection and not to absorption and we need not necessarily assume an atmosphere at all different from our own. Since the color effect at the limb is strongly marked, it would appear, if the above proposition is correct, that the atmosphere of Mars is probably not very different from our own in density. W. H. P.

In Professor Pickering's private letter accompanying the above note, he speaks of finding, in a recent expedition to one of the neighboring mountains a bed of red lava. Some of this lava exactly matches in color what Professor Pickering considers from his experiments to be the true color of the planet Mars.

Photographic Chart of the Sky.—The first part of volume two of the Bulletin of the International Committee has just come to hand. It contains a number of important papers by the members of the committee. M. Loewy discusses a method of determining the co-ordinates of the centers of the plates, making them depend not only on the few well determined stars which may occur on each plate but also upon those found on overlapping plates. In this way each plate may be referred to so many stars that it will not be necessary to undertake the labor of re-observing with meridian circles the 60,000 or 70,000 reference stars.

The committee charged with distributing screens to be used at the different observatories in determining the proper length of exposure for 11th magnitude stars, obtained discordant results in their experiments, the time ranging from $1^m\ 20^s$ to 7^m. It is probable that the plan of making three exposures of 6^m, 3^m and 20^s respectively on each region on the same night will be adopted for the plates from which the catalogue is to be constructed. The exposure for the chart plates will be uniformly 60^m. H. C. W.

Magnet-Meteorologico Observatorio Coimbra, Portugal.—We are indebted to Dr. Antonio de M. Garrido, Director of Observatorio Magnet-Meteorologico at Coimbra Portugal, for his annual publication for the year 1891. It gives an interesting cut of Observatory, the first we have seen of it.

Publicazioni Della Specola Vaticani Fascicolo II.—We are pleased to have received from the Observatory of the Vatican, Rome, Italy, by the kindness of the Director, P. François Denza, the above named publication for the year 1891. Besides the usual records pertaining to Meteorology and Astronomy, a series of fine plates are given showing the Observatory building, photographic instrument, plates of the Pleiades, Cluster on Sagittarius, Ring Nebula, real photographs of portions of the Moon and three photographs of Jupiter, two of which plainly show the red spot, and all give the belts with great distinctness. The equatorial diameter of the pictures of Jupiter is quite exactly one-half inch.

The Photo-chronograph applied to Determinations of Latitude.—This is the title of a paper just published by the Georgetown College Observatory. The new form of instrument used is that of a floating zenith telescope, similar to Dr. Chandler's Almucantar, with a photo-chronograph attached in the place of the micrometer eye-piece. The objective is a single combination of two lenses, corrected for photographic rays, aperture 6 inches and focal length 36 inches. It was made by Brashear and is found to be excellent, readily giving trails of stars below the 7th magnitude. The photo-chronograph was designed by Professor Geo. A. Fargis, S. J., and constructed by Mr. Saegmuller. It consists essentially of two occulting bars, which, by means of electro-magnets in connection with a clock, are made to alternately cover and uncover the portions of the sensitive plate upon which the star trail is being made, one of the bars serving for the north, the other for the south star. Pairs of stars are selected, as in the ordinary method of determining latitude with the zenith telescope, having nearly equal zenith distances, north and south, and the two stars are allowed to leave their trails on the same plate. The trails are broken up into series of dots by the clock moving the occulting bars each alternate second, and the beginning and middle of each minute is marked by the omission of a certain number of breaks. It is thus easy, knowing the time of transit of each star, to find the position of the meridian on the plate, so that the distance between the star trails may be measured in the meridian with a micrometer. The reductions are the same as in Talcott's method, except that the level correction and reduction to meridian are omitted.

A few preliminary results are given for the latitude of the Georgetown Observatory, which seem to indicate that the method can be relied upon to give more accurate results than the visual method, besides being much more comfortable for the observer. At the close of the paper the following announcement is made:

"The intention is to make this Observatory a *permanent station for studying the periodic variations of the Pole.* A second permanent latitude station is, at our instance, being erected at Manila, in the Philippine Islands. It will be furnished with a floating zenith telescope and latitude photo-chronograph like those here described. The future director of that station, Father Joseph Algué, S. J., is now at the Observatory, with the view of familiarizing himself with this method. Since Manila is almost opposite Washington in longitude, these two stations seem to be well adapted for controlling the periodic variations of the Pole by a uniform method, in a direction almost perpendicular to the meridians of Berlin and Honolulu, where simultaneous observations are carried on at present."

H. C. W.

Brilliant Aurora at Mt. Hamilton, June 26.—Last night at $12^h\ 15^m$, while photographing the Milky Way, my attention was attracted to a bright fiery illumination in the north and northeast. This proved to be a brilliant aurora. The northeast sky was suffused with a bright reddish glow extending nearly as high as the pole. Bright yellowish white streamers were shooting up from the horizon, but there was no arch. For the next half hour the display was very active and towards the last streamers made their appearance to the west of the pole. The activity gradually ceased, but the brightened glow continued visible in the north and northeast as late as $14^h\ 30^m$, when it could still be seen through the breaks in the clouds which then covered the sky.

The point of maximum action and illumination was about 15° east of the north point.

This makes the second aurora that I have seen at Mt. Hamilton, the first being on May 18 this year. See ASTRONOMY AND ASTRO-PHYSICS for June, 1892.

E. E. BARNARD.

Mt. Hamilton, 1892, June 27.

Comparison of Celestial Photographs.—In *Astr. Nach.*, No. 3101, Mr. Barnard suggests a very simple and rapid method of detecting changes on celestial photographs, due to motion or variability of the celestial bodies. This requires the two negatives to be on exactly the same scale. A positive on glass is made from the first negative and superposed upon the second, film to film. Since the scale is the same in each case the black images of the negative number two will blot out the white images of the positive, except where there has been change of position or loss of brightness of a star. Increase of brightness would be detected by superposing the first negative upon a positive of the second.

Another quite novel method of comparing plates was suggested to me this summer by Mr. Ritchey at Chicago. It was to project the two positives upon a screen at the same time with complementary colored lights, for instance red and blue of the proper shades. When the positives are carefully adjusted so that the corresponding images fall upon the same points of the screen, all stars having the same intensity of image on both plates will appear white. A star occurring on only one plate will be red or blue according to the color of the light projecting that plate. Variations of brightness of stars will be indicated by different tints of color, red or blue according as the star is more intense in the one plate or the other.

H. C. W.

Visit to Kenwood Physical Observatory.—We spent two very pleasant and profitable weeks at Mr. Geo. E. Hale's private Observatory at Kenwood, Chicago, during this summer. The equipment of this Observatory and the discoveries which have been made in it have been described in the earlier numbers of this journal, but one must actually see the apparatus and the photographic plates to fully appreciate what has been accomplished in the way of photographing the solar prominences and faculæ. The photographs of the faculæ are a revelation to one who has watched them visually or photographed them by the old methods from day to day and realizes over what a small portion of the solar disk they are thus seen. The extent of the area covered by the faculæ in these photographs is surprising. I have before me a positive of a photograph taken in February when the great spot was near the center of the Sun's disk. The faculous area is so conspicuous and extensive that the great spot in its center is almost insignificant in comparison. In another photograph taken a few days later when the great spot was near the west limb, the whole spot zone in the northern hemisphere is sprinkled over with brilliant faculæ. The careful examination and measurement of these photographs, taken daily and often many times each day cannot fail to add greatly to our knowledge of the Sun.

Mr. Hale has just added a new photographic objective to the telescope, making it a twin telescope, but with only one tube. The method of mounting the objectives is a novel one. They are placed in a twin cell which is hung on an axis at the side of the tube in such a way that either glass may be brought by rotation in front of the tube. They may thus be inter-changed in a few seconds. The tail-piece carrying the eye-pieces is also mounted at the side of the tube so that for visual observations the telescope without a tube is used. The definition seems not to suffer but rather to be possibly improved by this arrangement.

H. C. W.

Color of Sirius in Ancient Times.—Perhaps I may be allowed to offer a few remarks on Mr. See's interesting papers on this subject, particularly as he does me the honor in the second portion to refer to a letter of mine in the tenth volume of

the *Observatory*. He has gone into the matter exhaustively, and has somewhat altered my views in respect to it.

The color attributed by Al Sufi to a few of the stars would seem to be his own and not Ptolemy's, as he differs from the latter in calling Algol red and not Sirius. Plato Tibertinus appears to have made a very remarkable error in representing that the Arabian astronomers found only five red stars in their copies of Ptolemy, whereas they wrote five *nebulous* stars, his own enumeration of the latter. But it does seem strange that Schjellerup did not consult the Arabic originals, instead of this translation.

I withdraw my remark in the *Observatory* concerning the peculiarity of the expression *καλούμενος κύων καὶ ὑπόκιρρος*, because on consulting older editions of Ptolemy than that of Halma, I do not find the *καὶ* between the substantive and the adjective, Sirius being called *ὑπόκιρρος* exactly as Antares and Arcturus are.

We may differ with regard to the weight to be attached to the "rutilo cum lumine" of Cicero or the "rubra Canicula" of Horace. But Seneca really seems to have compared the color of Sirius with that of the planets and noticed that the star was more red than Mars, whilst Jupiter was not red at all. This last remark appears to me, on further consideration, to take away all probability from the suggestion of the Delphin editors that the true reading should be "fulgor" and not *rubor*. For Seneca could hardly have meant to say that the fulgor (brightness) of Jupiter was *nullus*. W. T. LYNN.

Blackheath, London, S. E., 1892, May 25.

Chicago Academy of Sciences.—*Section of Mathematics and Astronomy.*—At a meeting of the Chicago Academy of Sciences on May 10, 1892, it was moved by George E. Hale that authority be granted for the formation of a Section of Mathematics and Astronomy. The motion was duly seconded, and referred to the General Committee, which reported favorably at the general meeting of the Academy on June 14, 1892.

The first meeting of the Section was held at the Kenwood Astro-Physical Observatory, Chicago, on June 15, 1892, in joint session with the Chicago Section of the Astronomical Society of the Pacific. Gayton A. Douglas was in the chair. The Chair announced that several Sections of the Academy had recently been formed, and that all of them had met with marked success. Any present who wished to become members of the Academy could make application on blanks provided for the purpose.

The Section proceeded to elect officers to serve until January, 1893, with the following result: Chairman, George W. Hough; Recorder, George E. Hale: Executive Committee, Sherburne W. Burnham, Gayton A. Douglas, E. H. Moore, with Chairman and Recorder *ex officio*. The committee will prepare by-laws to be acted upon by the Section.

Professor Hough not being present, Mr. Douglas remained in the chair.

Professor Hale made some remarks on the work of the Academy and its signal success in the formation of Sections. He congratulated Chicago scientists in general and the Astronomical Section in particular on the fact that Mr. S. W. Burnham has returned to Chicago from the Lick Observatory, and will permanently reside here.

The Chair remarked that the present meeting occurred on the first anniversary of the dedication of the Kenwood Observatory, and called on Mr. R. W. Pike for remarks.

Mr. Pike spoke of the work accomplished at the Observatory during the first year of its existence, and said that he had found some interest taken in this work by astronomers whom he had recently met in various European observatories.

Professor Hale followed with an account of the investigations now in progress on the application of photography in recording the forms and spectra of the solar spots, faculæ, chromosphere and prominences. During the year 19 lines have been discovered in the ultra-violet prominence spectrum, the H and K lines

have been found to be reversed in all spots and faculæ, and a practical method of photographing the chromosphere, prominences, spots and faculæ in a single picture has been devised, and is now in daily use.

The Chair introduced Dr. S. H. Peabody, President of the Academy, and Chief of the Liberal Arts Department of the World's Columbian Exposition. Dr. Peabody spoke of Newton's early experiments with a round hole instead of a slit, and of the immediate results of Wollaston's substitution of a narrow slit years later. He thought that the advantages resulting from the application of photographic methods to solar study were almost comparable with that advance. He also alluded to Schwabe's long years of patient observation of Sun-spots, and pointed out the important aid of photography in such work.

The meeting then adjourned, and those present (about 125 in number) were given an opportunity of observing Saturn with the 12-inch telescope.

Applications for membership in the Academy have been received by the Recorder from the following persons, and placed in the hands of the Secretary of the Academy:

Resident Members.—R. W. Pike, 166 La Salle St.; Frank H. Dickey, 3626 Ellis Ave.; W. H. Hine, 324 Ogden Ave.; Mrs. W. H. Hine, 324 Ogden Ave.; F. W. S. Brawley, 3010 Lake Park Ave.; Cynthia L. Stone, 4544 Greenwood Ave., Chicago.

Associate Member.—Clifford C. Smith, No. 1036 "The Rookery," care of Ill. Steel Co., Chicago.

GEORGE E. HALE, Recorder.

Astronomical Society of the Pacific.—*Minutes of the meeting of the board of directors held at the Lick Observatory June 11, 1892.* President Schaeberle took the chair and a quorum was present. The minutes of the last meeting were approved. The 18 members following were elected: Mrs. H. R. Arndt, San Diego, Cal.; William W. Austin, Vineland, Cumberland Co., New Jersey; W. H. Devine, Nagasaki, Japan; W. S. Eichelberger, Wesleyan University, Middletown, Conn.; Professor R. Lee Hamon, Hyannis, Grant Co., Nebraska; Daniel Hanlon, 1627 Jackson Street, S. F., Cal., Mrs. Phebe Hearst, Care of W. R. Hearst, "Examiner," S. F., Cal.; Charles W. Holden, 30 Congress Street, Boston, Mass.; C. G. Hubbard, San José, Cal.; Donald King, 8 Church Lane, Strand, London, England; Frank McClean, M. A., F. R. A. S., Rusthall House, Tunbridge Wells, England; F. Martens, College Point, Queen's Co., New York; J. Messer, care of Carl Ricker, Nevsky Prospect, No. 14, St. Petersburg, Russia; Judge F. W. Miner, Providence, R. I.; James L. Park, Braddock, Pa.; T. J. J. See, Zimmer Str. 97 Berlin, Germany; W. T. Sulzer, Louisville, Ky.; Professor L. Weinek, Imperial Observatory, Prague, Austro-Hungary. The treasurer presented his report which was received and filed.

Mr. Pierson, of the committee on Observatory in San Francisco, reported that the Park Commissioners had kindly granted a site in Golden Gate Park for the proposed Observatory.

The following resolution was moved and seconded and postponed for further consideration:

Resolved, That the By-Laws (Art. II) be amended by abolishing the status of Honorary and Corresponding members and making the necessary verbal changes. (See *Publ. A. S. P.*, Vol. III, page 194.)

Minutes of the meeting of the Astronomical Society of the Pacific held at the Lick Observatory, June 11, 1892. President Schaeberle presided. The minutes of the last meeting as printed in the *Publications*, were approved. A list of presents was read by the Secretary, and the thanks of the Society voted to the givers.

Special attention was called to the beautiful album of engravings of the buildings and instruments of the Nice Observatory, presented by Mr. Bischoffsheim, the founder of the Observatory, and to the very rare medal of the Great Comet of 1680 referred to in *Publ.* A. S. P., Vol. II., page 124, presented by Professor Holden.

The Secretary read the names of members duly elected at the meeting of the Directors. The following programme was presented:

1. The Lunar Eclipse of January, 1888, by Professor Weinek, of Prague.
2. The Proper Motions of Stars with different Spectra, by W. H. S. Monck, of Dublin.
3. The McCormick Observatory, by H. A. Sayre, of the University of Virginia.

4. A Trial of Foucault's Pendulum Experiment, by Torvald Köhl, of Denmark.
5. Notice regarding the Astronomical Exhibit at the World's Fair, by Geo. E. Hale, of Chicago.
6. Verbal Accounts, by Professors Schaeberle and Campbell, of Observations of the spectrum and magnitude of the new star of 1892; of photographic observations of the Great Sun Spot of February, 1892; and of observations of the spectrum of Swift's comet. Illustrated by photographs made at the Lick Observatory.

Recent enlarged photographs of Venus and of Saturn made with the 36-inch equatorial and an enlarging lens by J. A. Brashear were exhibited to the members as well as similar photographs (by Professor Schaeberle) of the region near the New Star in Auriga; photographs and drawings (by Professor Campbell) of the spectrum of the New Star and of Swift's comet; and some very successful photographs of stellar spectra taken in the 2d and 4th orders of a Rowland grating of 14,000 lines; etc., etc. Adjourned. F. R. ZIEL, Secretary.

The Astronomical and Physical Society of Toronto.—We notice with interest the reports of the meetings of the Astronomical and Physical Society of Toronto in the various papers of that place. Since our last issue several extended reports of the society's meetings have been published, which not only indicated unusual interest in the chosen field of the society, but also show a zeal in doing some useful work in lines of science open to this new organization.

The meeting of July 4 presented an excellent programme, and a pretty full report of it is given below, as it appeared in the Toronto *Surprise:*

Among the communications read were letters from Miss Agnes M. Clerke, of London, England, a writer of high rank on astronomical subjects, and a corresponding member of the society, who sent in a paper entitled "Nova Aurigæ;" from Mr. J. Ellard Gore, F. R. A. S., and from the directors of the Observatories at Melbourne, Australia, and Bothkamp, Germany. Orders for copies of the society's last report were also received. Lady Wilson, of Toronto, was elected a life member, and several names were proposed for active and corresponding membership. A committee was appointed to take action in respect to the proposal to induce astronomers to reckon the astronomical day from midnight instead of from noon, as now. Interesting drawings of solar prominences were received from Mr. A. F. Miller, and of Mars from Mr. Arthur Harvey, who also reported having observed on the 25th of June a well-defined parhelion, a phenomenon unusual at this season of the year.

The paper for the evening, "Stellar Distances and Motion," had been received from Mr. J. Ellard Gore, a valued contributor to scientific publications and the author of several excellent works on astronomy. It consists of a chapter from his forthcoming book, "The Visible Universe," and had beed sent in advance of publication by special permission of his publishers, Messrs. Crosby, Lockwoow & Son, London, England, who own the copyright. In his lucid and attractive style Mr. Gore showed that the determination of the distance of the stars from the Earth has always formed a subject of great interest to astronomers, and that a knowledge of the relative distances of bright and faint stars is of the highest importance in the study of sidereal astronomy, it being evident that if we could accurately find the distance of every star and also the distances of the brighter and fainter portions of the Milky Way, the problem of the construction of the stellar heavens would be immediately solved. Notwithstanding the use of modern instruments of precision, the distances of but few stars have been ascertained with any approach to accuracy. In the course of his admirable paper, the author referred to the earlier astronomers, including Tycho Brahe, Kepler and Huyghens, some of whom thought the stars had no measurable parallax, and others that the determination of the stellar distance by observations was impossible; Sir William Herschel, who, while working vainly upon the problem, made the splendid discovery of binary systems; to the parallax of fixed stars and the method of determining it; to the methods of computing a star's distance in miles by simply multiplying the Sun's distance by 206,265, and dividing by the observed parallax, and of reducing distances to "light-years;" to the fact that the brightness of a star is no test of its distance; to the use of the spectroscope in determining the motion of stellar objects moving in the line of sight, and, among other branches of his subject, to the discovery that the solar system is itself in motion towards a point in Hercules, a constellation overhead at Toronto every evening at an early hour.

XUM

The predictions included the occultation by the Moon of 25 Scorpionis at 12:41 A. M., July 7; of B.A.C. 6,666 at 7:40 P. M., July 9, of 35 Capricorni at 8.23, July 11, and, on the same evening, of the planet Mars shortly after 11 o'clock. The Moon, which will be about two days past the full phase, will rise at 9.41 with the planet a little to the east of it. Mars will disappear behind the bright limb of the Moon, and should reappear from behind the shaded limb about 12 minutes after midnight. The phenomenon, which will be visible to the naked eye, is not a common one, and will prove to be worth careful observation by amateurs; any telescope, and almost any opera-glass, will greatly add to the interest of the occultation.

BOOK NOTICES.

High School Algebra, embracing a complete course for High Schools and Academies. By William J. Milne, Ph. D., L.L. D., President of New York State Normal College, Albany, N. Y. "Milne's Inductive Algebra" revised and enlarged. Published by the American Book Company, New York, Cincinnati, and Chicago.

In the revision of this Algebra, the author has kept steadily in mind the "inductive idea" in teaching, which he thinks worthy of a prominent place. In this he is certainly right in a very important sense. In training a student in Algebraic processes, it is one thing to work mainly for a result, it is quite another thing to seek for a result by a clear and definite logical process. The student naturally will work for an answer, often think little, and sometimes care little about his method of argument, provided it does not involve manifest absurdity. At this point, more than any other, are the book and instructor valuable. If these guide the student wisely, interest and growth of mental power always follow.

The inductive plan, so called, consists in first giving a considerable number of mental exercises which are intended to bring to the mind of the student the ideas of the definitions to be stated in careful way later, and which are appropriate to the subject under consideration. After the definitions belonging to the topic are given there follows a statement of principles, set out plainly in suitable type, so as to gain the attention fully and properly relate them to other secondary work intended only for illustration. It is a hard thing for a student to learn that a problem or, an example even, is intended *only* to illustrate a principle. The plan of this book, in this respect, is quite like that used by Mr. E. E. White in his complete arithmetic. That book is well known among teachers for its excellence.

The range of topics of this algebra is abundantly wide, examples varied and numerous, and there is a useful series of review exercises at its close. The printing and paper are excellent and it is the best bound text-book we have seen in many a day.

A Treatise on Plane and Spherical Trigonometry, by E. Miller, A. M., Professor of Mathematics and Astronomy in the University of Kansas. Publishers, Messrs. Leach, Shewell and Sanborn, Boston and New York.

Within a compass of 110 pages, Professor Miller has given us the essentials of Trigonometry in this new book. His definitions are well stated, illustrations clear, figures good, and examples sufficient for practice, though not as abundant as in some late authors. Almost exactly one-half of the book is devoted to spherical Trigonometry, which treats this part of the study more generally than elementary text-books usually do. The formation of the fundamental formulæ is at once undertaken by the aid of geometrical figures which involve the use of the polar triangle. While this is an excellent way to instruct students in Trigonometry who have had some experience, it seems to us that it would be a severe

method for those who are pursuing the study for the first time, especially if they have not had the preparatory training in Plane Trigonometry which involves large use of formulæ and functions. We are aware that the author has adopted Chauvenet's good ideas here, and we know they are good from actual test in past studies in this branch, but what we fear in the arrangement of matter is the difficulty of the task which the beginner will be asked to undertake before he has sufficient foundation in spherical thinking to enable him to carry the processes without undue strain or discouragement. If sufficient time be given to the work, and the daily assignments of lesson be sufficiently limited, of course the book may be used successfully. The instructor would have to be on his guard continually to avoid assigning too much or he would overtax the student or cause him to make imperfect preparation. We have little doubt but that Professor Miller would know how to use this book, but we fear many others would fail in trying it. The sets of examples furnish a thorough review of principles of Trigonometry, and the student who masters them all would certainly be entitled to a good standing in the branch in any college.

The publishers have made a neat and a very attractive book, and we are sure that those interested in teaching Trigonometry will be profited by its thorough examination. The book is not provided with logarithmic or trigonometric tables.

A Drill Book in Algebra. By Professor George William Jones, of Cornell University. First edition. Published by George W. Jones, Ithaca, N. Y., 1892, pp. 272, 12 mo. Cloth. By mail 60 cents. An answer book and a box of question cards in preparation.

This is the fourth book in the mathematical series by Professor Jones already published, and is designed for the more advanced classes in the High Schools and Academies and for lower classes in the Colleges. The name of Drill-book is well chosen. It is exactly that. The book presents nine different topics, viz.: The primary operations of arithmetic, the primary operations of algebra, simple equations, measures and multiples, variations, proportions, inequalities, incommensurable numbers, powers and roots, quadratic equations, the three progressions, logarithms, permutations, combinations and probabilities. Under each of these topics there are from four to seven sub-heads, or sections, which discuss the different features of the topic, closing a series of questions for review appropriate to the same. It is easy to see how a live teacher with such a book as this in hand could easily arouse a class of students to high endeavor and useful result. We are sure teachers of algebra will be interested in examining this new book. Its cost is remarkably small.

Determinants. An introduction to the study with examples and applications by G. A. Miller, Ph. D., Professor of Mathematics in Eureka College, and published by the D. Van Nostrand Company, 23 Murray and 27 Warren streets, New York. 18 mo. Boards, pp. 110. Price 50 cents, 1892.

This little book is No. 105 of Van Nostrand's Scientific Series, and it is the first of that series that we have seen. We think enough of it, to put it into our pocket to read at odd spells, so as to have a little mental recreation when chance opportunity is offered. Any student wanting a good introduction to Determinants in convenient form, may profitably examine this book. The topics briefly and plainly treated are as follows: History of Determinants, nature of Determinants, Inversions and permutations, meaning of notation, different methods of notation, Determinants of the second order, Determinants of the third order, increasing the order by borders, Complementary minors, applications to linear equations, consistence of linear equations, factors of a Determinant, multiplication of Determinants, symmetrical Determinants and elimination.

Abroad and at Home is a neat book of 251 pages by Morris Phillips, editor of "Home Journal," New York, published by the Brentanos, Paris, Washington, Chicago and London, containing practical hints for tourists.

Within so narrow a compass this book gives to the tourist a good introduction to principal points on main thoroughfares in Great Britain and Paris if going abroad, and if traveling in the United States, of course, the sight-seer must visit Georgia, Florida or California, and the resorts in these directions are alluded to in the latter part of the book in helpful way.

XUM

Errata in Article on Color of Sirius.—Below will be found a list of corrections which Mr. See wishes to be noted in reading his article on the History of the Color of Sirius. Some errors were due to proof readers. The copy of the Greek words was in script and some of them very uncertain. A number of changes indicated were not in the copy, as we notice by comparison:

Page 270, line 3, *ἐπίκλησιν*; line 6, read *χαλκὸς*; line 8, read *πυρετός*; line 16, read *the* Scorpion, [*the* was not in copy]; bottom line read *παμφαίνῃσι*. Page 272, under Aratus line 6, Myron. Under Geminus, first line of Greek read (*κύων*); last line *κυνὸς*. In this passage *ἀποφορά* had better be translated "influences" instead of "exhalations." Page 273, line 2, read Matthiæ. In the Greek of Erastosthenes the semi-colons (·) should be inserted after *λέγεται* and *καλουσι*. Page 374, in the second quotation from Cicero read candoremque, (copy bad). Page 375, first quotation from Plutarch the accent on *Ἰσιδος* is somewhat misplaced. In the second quotation from Plutarch the first word should be *Λίβυες*; in the last, read *τὸν δὲ Κύνα*. In the last word cited from Photius there should be a final *ν*, it was not in copy. The king of Egypt referred to should be Ptolemy III-Euergestes I. Page 375 last line, read *εἰμι*. Page 376 under Horace first line of quotation read reducto. Page 377, in quotation from Seneca read Martis. Page 378, in quotation from Columella, first line, read Dionaeis, and insert comma after hortus; the comma after Cultu should stand after Hortorum (omitted from copy in both cases). Page 379, under Festus, 9th line from bottom, the comma after word should stand after Catularia (not in copy). Page 380, under Ptolemy, *καλουμενος* should not have capital *κ*, and *Κύωνν* should be accented (copy uncertain). Mr. Bailey's name is Francis. The summary is capitalized exactly as the copy. Copy of this kind in the future will not be accepted unless better.

PUBLISHER'S NOTICES.

The subscription price to ASTRONOMY AND ASTRO-PHYSICS in the United States and Canada is $4.00 per year, in advance. For foreign countries it is $4.40 per year which is the uniform price. Messrs. Wesley & Son, 28 Essex Street, Strand, London, are authorized to receive subscriptions. Payment should be made in postal notes or orders or bank drafts. Personal checks for subscribers in the United States may be used.

Currency should *always* be sent by registered letter.

Foreign post-office orders should *always* be drawn on the post-office in Northfield, Minnesota, U. S. A.

All communications pertaining to Astro-Physics or kindred branches of Physics should be sent to George E. Hale, Kenwood Astro-Physical Observatory Chicago, Ill.

All matter or correspondence relating to General Astronomy, remittances, subscriptions and advertising should be sent to Wm. W. Payne, Publisher of ASTRONOMY AND ASTRO-PHYSICS, Goodsell Observatory of Carleton College, Northfield, Minn.

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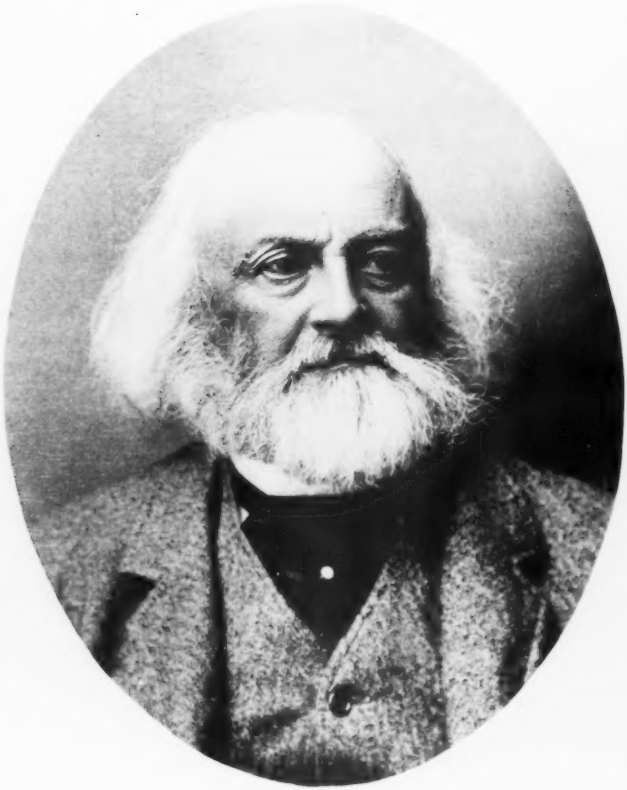
PLATE XXVII.



LEWIS MORRIS RUTHERFURD.